

MAY 1954



VOL. 46 • NO. 5

Journal

AMERICAN
WATER WORKS
ASSOCIATION

In this issue

Effects of Illinois Drought	Buswell
Watershed Control	Hopkins, Jester, Dodson, Lavery, Thompson
Texas Water Resources	Rollins, Bouldin
Houston's San Jacinto Project	Baldwin et al.
Hydrologic Study of San Jacinto Basin	Jens
Metaphosphate and Corrosion	Lamb, Eliassen
Sea Water Distillation Scale Control	Langelier
Ion Exchangers in Water Analysis	Calmon, Navone
Lauryl Sulfate Tryptose Medium	Bicknell, Middleton, Neblett
Customer Accounting	Hammes
Effects of Water Softening With Lime	Riehl, Hartung, Taylor



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AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y.

Phone: MUrray Hill 2-4515

May 1954

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Contents

Effects of Drought in Illinois.....	ARTHUR M. BUSWELL	395
Views on Watershed Control		
Eastern States.....	EDWARD S. HOPKINS	403
Washington Suburban Sanitary District.....	JOHN M. JESTER	408
San Diego.....	ROY E. DODSON JR.	409
East Bay District.....	GORDON L. LAVERTY	414
New Mexico.....	FRED A. THOMPSON	416
Need for Water Resources Conservation in Texas.....	A. P. ROLLINS	418
Legal Aspects of Water Resources Development in Texas...	VICTOR W. BOULDIN	421
San Jacinto Water Supply for Houston		
F. N. BALDWIN, G. L. FUGATE, C. R. HARVILL, M. A. DILLINGHAM,		
F. H. NEWNAM JR., N. P. TURNER, L. H. EARNEST &		
W. K. VAN ZANDT		425
Hydrologic Considerations in the San Jacinto Project.....	STIFEL W. JENS	438
Mechanism of Corrosion Inhibition by Sodium Metaphosphate Glass		
JAMES C. LAMB III & ROLF ELIASSEN		445
Mechanism and Control of Scale Formation in Sea Water Distillation		
W. F. LANGELIER		461
Use of Ion-Exchange Methods in Water Analysis.....	CALVIN CALMON	470
Sodium Determination With Ion-Exchange Resin.....	REMO NAVONE	479
Lauryl Sulfate Tryptose Broth as a Presumptive and Confirmatory Medium for		
Coliform Organisms		
ALICE K. BICKNELL, JOHN MIDDLETON & THOMAS NEBLETT		481
Customer Accounting at Sheboygan.....	J. ALLAN HAMMES	486
Effects of Lime Softening		
MERRILL L. RIEHL, HERBERT O. HARTUNG & FRANK S. TAYLOR		493

Departments

Officers and Directors.....	2 P&R	The Reading Meter.....	50, 98 P&R
List of Advertisers.....	4 P&R	Condensation.....	62 P&R
Coming Meetings.....	6 P&R	Membership Changes.....	88 P&R
Percolation and Runoff.....	31, 74 P&R	Service Lines.....	102 P&R
Correspondence.....	48 P&R	Section Meetings.....	104 P&R

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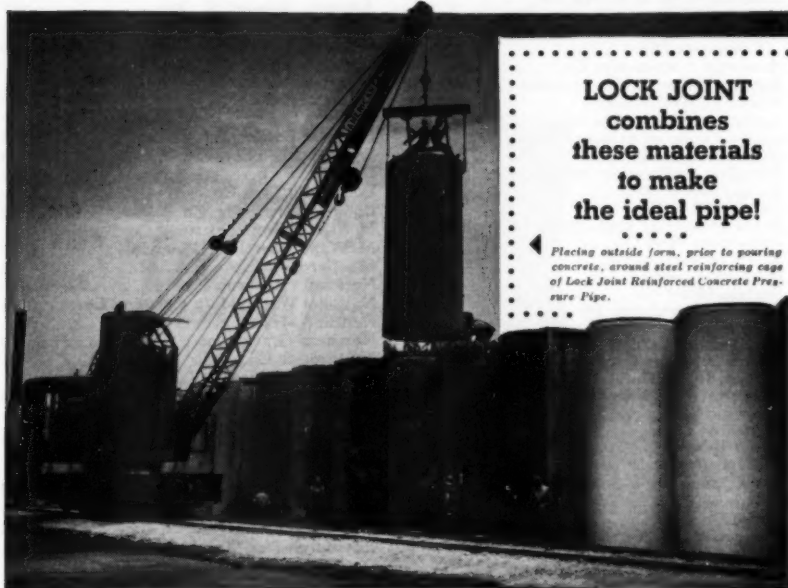
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LIST OF ADVERTISERS

	P&R PAGE		P&R PAGE
Alabama Pipe Co.	—	Inertol Co., Inc.	25
Allis-Chalmers	18, 19	Inflico Inc.	113
American Agricultural Chemical Co.	100	Iowa Valve Co.	20, 83, 109
American Brass Co., The	—	Johns-Manville Corp.	9
American Cast Iron Pipe Co.	—	Johnson, Edward E., Inc.	108
American Concrete Pressure Pipe Assn.	17	James Jones Co.	10
American Cyanamid Co., Industrial Chemicals Div.	70	Keasbey & Mattison Co.	14
American Locomotive Co.	23	Kennedy Valve Mfg. Co., The	—
American Pipe & Construction Co.	105	Kitson Valve Div.	—
American Well Works	21	Klett Mfg. Co.	90
Anthracite Equipment Corp.	66	Koppers Co., Inc.	47
Armco Drainage & Metal Products, Inc.	51	Layne & Bowler, Inc.	101
Atlas Mineral Products Co., The	—	Leadite Co., The	Cover 4
Backflow Engineering & Equipment Co.	99	Leopold, F. B.	94
Badger Meter Mfg. Co.	36-37	Lock Joint Pipe Co.	3
Barrett Div., The	89	Ludlow Valve Mfg. Co.	42
Belco Industrial Equipment Div.	88	M & H Valve & Fittings Co.	49
Bethlehem Steel Co.	—	McWane Cast Iron Pipe Co.	75
B-I-F Industries, Inc.	28, 63, 82	Mueller Co.	53
Blockson Chemical Co.	41	National Cast Iron Pipe	20, 83, 109
Buffalo Meter Co.	88	National Water Main Cleaning Co.	65
Builders-Providence, Inc.	82	Neptune Meter Co.	5
Calgon, Inc.	—	Northern Gravel Co.	78
Carborundum Co., The	—	Northrop & Co., Inc.	68
Carlson Products Corp.	97	Omega Machine Co. (Div., B-I-F Indus- tries)	28
Carson, H. Y., Co.	94	Ozone Processes Div.	—
Cast Iron Pipe Research Assn., The	26, 27	Pacific States Cast Iron Pipe Co.	75
Cathodic Rustproofing Co.	—	Pekrul Gate Div., (Morse Bros. Machin- ery Co.)	—
Centriline Corp.	11	Permutit Co.	73
Chain Belt Co.	103	Phelps Dodge Refining Corp.	95
Chicago Bridge & Iron Co.	15	Philadelphia Gear Works, Inc.	96
Clow, James B., & Sons	20, 83, 109	Pittsburgh-Des Moines Steel Co.	—
Cochrane Corp.	45	Pittsburgh Equitable Meter Div. (Rock- well Mfg. Co.)	118
Crane Co.	39	Pollard, Jos. G., Co., Inc.	93
Darley, W. S., & Co.	106	Portland Cement Assn.	—
Darling Valve & Mfg. Co.	35	Precision Machine Co.	—
De Laval Steam Turbine Co.	87	Proportioners, Inc.	63
DeZurik Shower Co.	—	Reilly Tar & Chemical Corp.	77
Dorr Co., The	Cover 3	Rensselaer Valve Co.	55
Dresser Mfg. Div.	—	Roberts Filter Mfg. Co.	43
Eddy Valve Co.	20, 83, 109	Rockwell Mfg. Co.	118
Electro Rust-Proofing Corp.	111	Rohm & Haas Co.	—
Ellis & Ford Mfg. Co.	—	Ross Valve Mfg. Co.	12
Everson Mfg. Corp.	24	Schleicher, Carl, & Schuell	—
Filtration Equipment Corp.	98	Simplex Valve & Meter Co.	91
Fisher & Porter Co.	79	Skinner, M. B., Co.	98
Flexible Sales Corp.	56	Smith, A. P., Mfg. Co., The	29
Ford Meter Box Co., The	8	Stuart Corp.	—
Foster Engineering Co.	—	Sundheimer, Henry, Co.	92
Foxboro Co.	—	Tennessee Corp.	85, 106
General Chemical Div., Allied Chemical & Dye Corp.	—	U.S. Pipe & Foundry Co.	7
General Filter Co.	71	Universal Concrete Pipe Co.	64
Golden-Anderson Valve Specialty Co.	—	Walker Process Equipment, Inc.	—
Graver Water Conditioning Co.	117	Wallace & Tiernan Co., Inc.	30, 69
Greenberg's, M., Sons	16	Well Machinery & Supply Co.	22
Gulf States Asphalt Co.	—	Welsbach Corp.	—
Hagan Corp.	—	Wheeler, C. H., Mfg. Co.	—
Hammond Iron Works	—	Wood, R. D., Co.	Cover 2
Harco Corp.	13	Worthington-Gamon Meter Div.	115
Hays Mfg. Co.	107		
Hellige, Inc.	—		
Hersey Mfg. Co.	67		
Hungerford & Terry, Inc.	110		
Hydraulic Development Corp.	81		
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co.	33		

Directory of Professional Services—pp. 57-61 P&R

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AWWA ANNUAL CONFERENCE

Seattle, Wash.

May 23-28, 1954

AWWA SECTIONS

May 25—Pacific Northwest Section luncheon meeting at Norselander Cafe, Seattle, Wash. (Business meeting only; to be held during AWWA Conference May 23-28.)

Jun. 22—New Jersey Section Summer Outing (inspection trip and luncheon) at Boonton. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

Jun. 23-25—Pennsylvania Section at Americus Hotel, Allentown. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

FALL SECTION MEETINGS

Sept. 9-10—New York, in Montauk, L.I.

Sept. 15-17—Michigan, in Muskegon

Sept. 20-22—Kentucky-Tennessee, in Nashville

Sept. 22-24—Ohio, in Dayton

Sept. 26-28—Missouri, in Jefferson City

Sept. 28-30—Wisconsin, in Green Bay

Oct. 6-8—Minnesota, in St. Paul

Oct. 13-15—Iowa, in Cedar Rapids

Oct. 17-20—Southwest, in El Paso, Tex.

Oct. 24-27—Alabama-Mississippi, in Birmingham

Oct. 26-29—California, in Long Beach

Oct. 27-29—Chesapeake, in Baltimore

Nov. 3-5—Virginia, in Richmond

Nov. 4-6—New Jersey, in Atlantic City

Nov. 7-10—Florida, in St. Petersburg

Nov. 8-9—West Virginia, in Huntington

Nov. 8-10—North Carolina, in Asheville

Nov. 9-10—Rocky Mountain, in Colorado Springs

OTHER ORGANIZATIONS

May 30-Jun. 5—Short School and Conference for Water and Sewage Works Operators at Univ. of Florida, Gainesville

Jun. 13-18—American Society for Testing Materials, in Chicago

Jul. 25-31—Inter-American Conference of Sanitary Engineering, in Sao Paulo, Brazil.

Aug. 3-13—Pan-American Federation of Engineering Associations (UPADI) at Sao Paulo, Brazil

Oct. 4-6—New England Water Works Assn., Poland Springs, Me.

Oct. 11-14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.

Oct. 11-15—American Public Health Assn., in Buffalo

Oct. 17-20—American Society of Civil Engineers, in New York City

Oct. 19-20—Public Utilities Sessions, National Safety Congress, Chicago

Oct. 19-22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 17-19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 28-Dec. 3—American Society of Mechanical Engineers, in New York



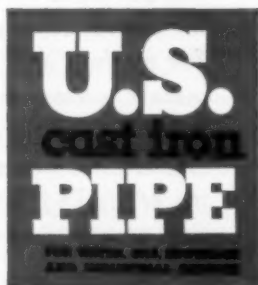
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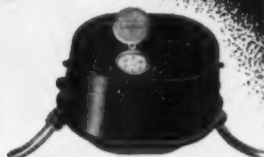
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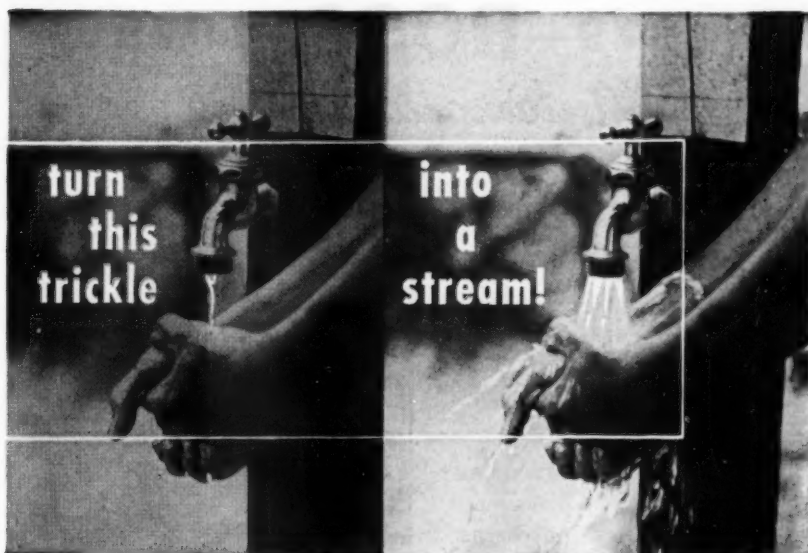


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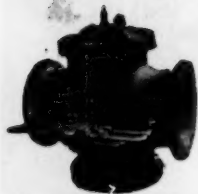
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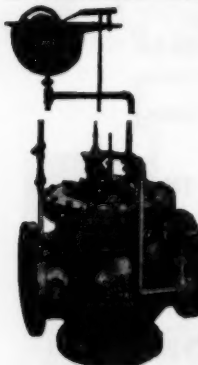
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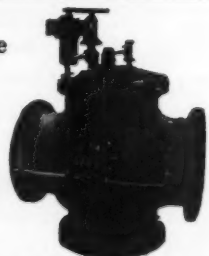
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"Century" pipe meets the A.W.W.A., A.S.T.M. and Federal Specifications for asbestos-cement pressure pipe.



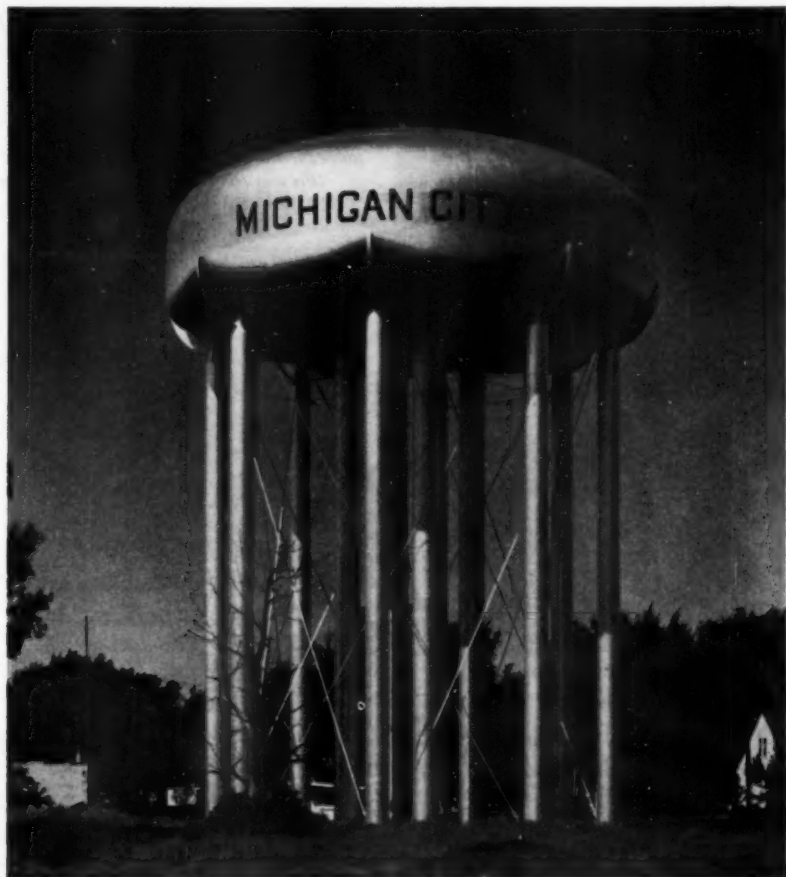
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1854 saw the beginning of a remarkable
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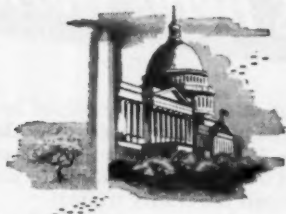
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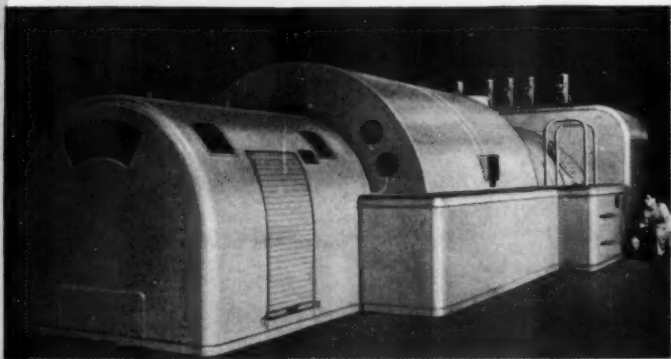
When *your city* plans expansion or modernization, do as Lakeland and other leading cities are doing — take advantage of Allis-Chalmers experience as builder of the world's widest range of public works equipment. Literature on all products available; Public Works Bulletin 25C6607A and Pump Bulletin 08B6146B just off the presses. For your copies, just call your nearest A-C sales office or write to Allis-Chalmers, Milwaukee 1, Wisconsin.

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POWER TRANSFORMERS were furnished by Allis-Chalmers. Those above are 833 kva, single phase, self-cooled units in Lakeland suburban substation. Other electrical equipment supplied includes controllers for the 150 hp deep well pump motors.

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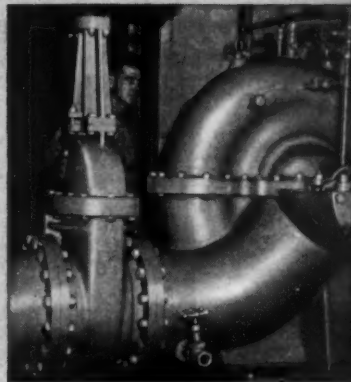
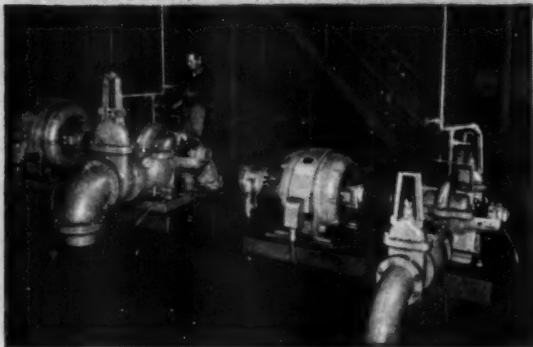




Citrus Center' Expand Water Works

LAKELAND FROM THE AIR, looking east. Over 600,000 people live in a 50 mile radius from Lakeland, Fla. Old power house, containing two Allis-Chalmers 5000 kw steam turbine generator units and associated equipment, is on left shore of Lake Mirror in center of above photograph.

CITY MAINS ARE SUPPLIED by Allis-Chalmers pump-motor teams ranging in capacity from 2000 to 4000 gpm each. Typical setup shown below: at left is a 12 x 10 in. pump rated 4000 gpm at 160 ft head, driven at 1800 rpm by 200 hp motor. At right is a 2000 gpm, 8 x 8 in. pump driven by a 100 hp, 1800 rpm synchronous motor.



PUMPS RANGE IN SIZE from 1 1/4 x 1 1/4 in. to this 16 in., 6000 gpm, 16 ft head unit furnishing condenser cooling water in old power house. Here Allis-Chalmers supplied two 5000 kw steam turbine generator units, boiler feed and condenser circulating water pumps, and crane m-g set.

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Close *against* the pressure to eliminate water hammer, provide flushing action.

Assure positive drainage.

Are available for any type of connection.

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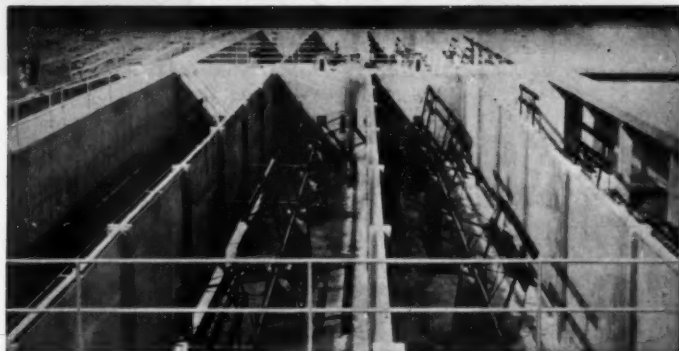
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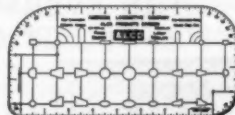
Consider Electric Welded Steel Pipe for your installation—special or standard, whatever its size. For complete technical data—and expert assistance with your special problems—contact your nearest Alco Products sales representative.



THE WORLD'S LARGEST water system grows even larger as New York City's Borough of Queens adds 17,250 ft of 72-in. and 1000 ft of 60- to 20-in. Alco Electric Welded Steel Pipe.

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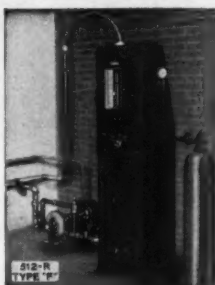
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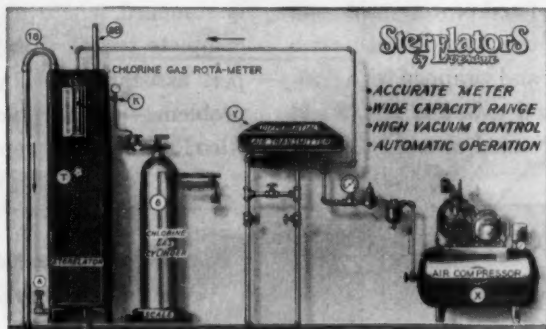
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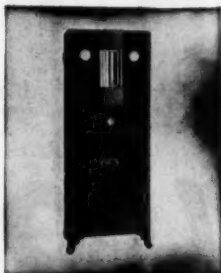
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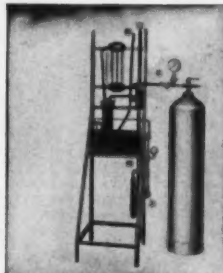
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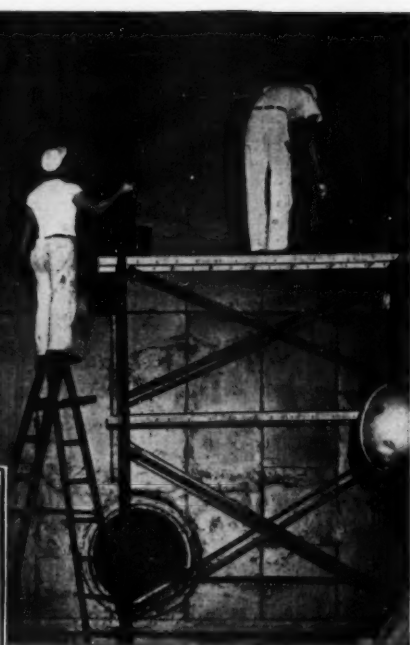
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Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.



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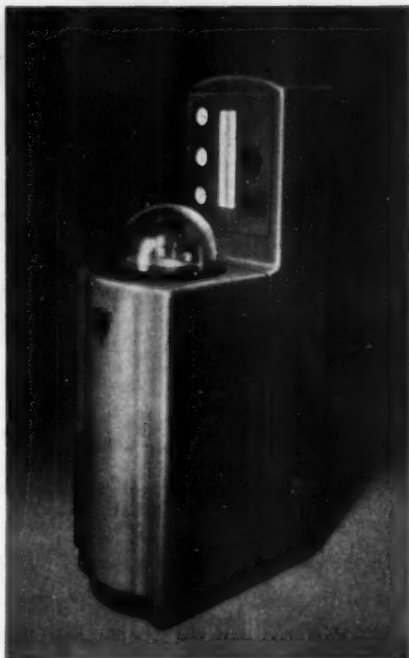
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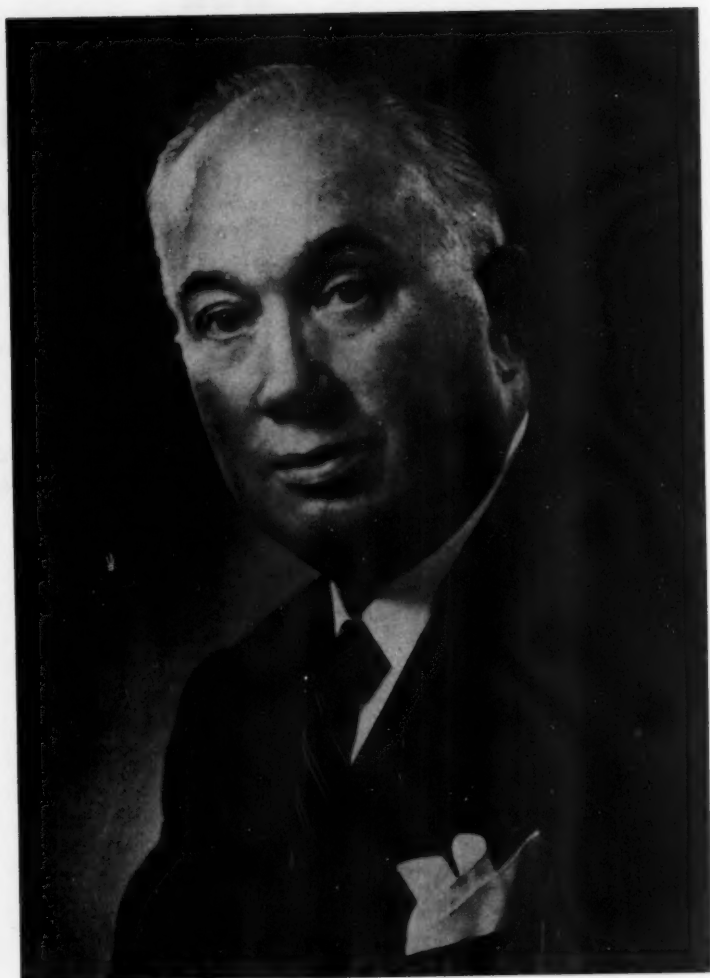
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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 46 • MAY 1954 • NO. 5

Effects of Drought in Illinois

By Arthur M. Buswell

A paper presented on Mar. 18, 1954, at the Illinois Section Meeting, Chicago, by Arthur M. Buswell, Chief, State Water Survey, Urbana, Ill.

PROGRESS in meteorology during the last 20 years has shown that certain atmospheric flow patterns are responsible for the drought conditions that have prevailed over much of the United States (1). For example, it is known that a northwesterly flow of wind at 10,000 ft between a ridge of high pressure in the western United States and a trough of low pressure in the east favors dry weather, particularly during the cooler part of the year. During the summer, however, when wind speeds and wavelengths are smaller than in winter, drought is generally found below a strong warm high-pressure system, known as the great American high-level anticyclone. In Fig. 1, the mean position of this large high-pressure system during June-August 1953 is shown centered over the Gulf States. Such a condition offered little opportunity for appreciable atmospheric moisture to move into the central United States from the Gulf of

Mexico, as the flow pattern was predominantly from west to east. Furthermore, this condition prevented deep cold-air masses from penetrating the country, and therefore minimized the opportunity for intense cyclonic developments, which are favorable to the production of precipitation.

Departures from normal rainfall are larger in southern than in northern Illinois, apparently because migratory cyclones in North America during recent months have been moving generally east southeast across Canada and the northern United States. Northern Illinois would be more influenced by these storms than southern Illinois and, hence, would receive more precipitation.

The nation as a whole has now experienced a 12-year drought period, which began in Arizona in 1942 and, with minor setbacks, had extended its influence eastward and northward into Texas and Oklahoma by 1952 (2).

Since 1952 it has spread across the Mississippi Valley into Illinois, Indiana, and Ohio (3). The drought pattern was partially interrupted by rains in Texas and Oklahoma in December 1953, but a continuous pattern through January 1954 exists in a belt across

greater than 7 in.: 10.63 in., 1901; 8.46 in., 1930 (with an additional deficiency of 3.5 in. through April 1931); 7.72 in., 1940; 7.46 in., 1894; and 7.36 in., 1914. It is significant that four of these subnormal periods were preceded and succeeded by at least normal pre-

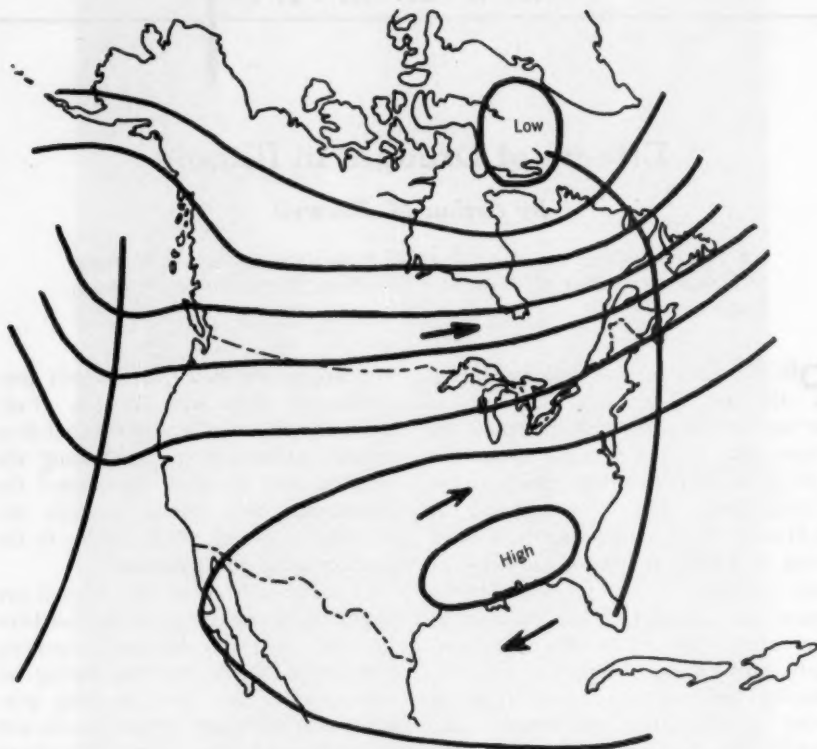


Fig. 1. Wind Flow Pattern

This US Weather Bureau map (1) shows the pattern at 10,000 ft during Jun. 1-Aug. 30, 1953.

Kansas, Missouri, Illinois, Indiana, and Ohio.

Weather Bureau records indicate that from 1878 to 1952 there were 5 years when the rainfall deficiency in the southern two-thirds of Illinois was

precipitation. The exception was the period 1939-40, when two consecutive years of deficient precipitation occurred. In the present drought, there has been deficient precipitation over the southern two-thirds of the state

throughout 1952 and 1953, and into 1954. The 1953 deficiency was 9.18 in.

Progress of Drought in Illinois

Figure 2 shows the progress of precipitation deficiencies occurring in Illinois from Apr. 1, 1952, through Jan. 31, 1954. (Negative numbers indicate inches of deficiency.) The cumulative departures from normal precipitation for the period April–December 1952 are given in Fig. 2a. Deficiencies varying from 5 to 10 in. occurred over the southern two-fifths of the state. A 5-in. deficiency also occurred in the extreme northwest corner of Illinois. The northern half of the state had normal precipitation, and, in one area, there was an excess of 10 in. above normal, brought about by the rainstorm of Jul. 18–19, when more than 11 in. of precipitation was gaged in a 36-hr period.

During the period April 1952–August 1953 (Fig. 2b) the situation worsened over most of the state. Deficiencies reached 10–15 in. over large areas. The effect of one heavy storm was limited to a small area.

The cumulative departures from normal for the entire drought period, April 1952 through January 1954, are shown in Fig. 2c. The greatest deficiency, 30.54 in., occurred in southwestern Illinois, where the drought pattern seems to center. Through the middle part of the state and most of the northern section, deficiencies of 5–10 in. predominated, although there were two areas in east-central Illinois that had excesses of precipitation (Watseka, 11.75 in., and Bloomington, 6.81 in.) due to heavy rains in July 1953.

Figures 2d–2i show the development of the rainfall deficiency in successive months, starting with the period from April 1953, the first dry month of that

year, through August 1953. In Fig. 2d, the –5-in. line slopes diagonally across the state from northwest to southeast. Stations at Quincy and Griggsville reported deficiencies greater than 10 in. (10.87 in.).

The September deficiencies (Fig. 2e), which averaged 2.84 in. in the southern third of the state and 2.09 in. in the central third, increased the accumulated deficiency for the period April through September so that the –10-in. line shifted to include a larger area in southwestern Illinois. The –5-in. line was now definitely in the northern half of Illinois, and a second 10-in. deficiency area was developing around Olney in Richland County. Both the northeast and the northwest corners of the state were beginning to show deficiencies, although the values reported at the end of September were only 5 in. below normal precipitation.

During October (Fig. 2f) there was some recovery in portions of southern Illinois. Both Albion and Mt. Carmel in southeastern Illinois reported more than 3 in. of precipitation, and the southern two-thirds of the state had an average deficiency of approximately 1 in. for the month. Meanwhile the northern third of the state reported a deficiency of 1.40 in. Most of the state had at least a 5-in. deficiency in precipitation, and a 15-in. deficiency appeared at Pittsfield in Pike County. In addition to the 10-in. deficiency circle near Olney, a new one developed in the southeastern part of the state, near Elizabethtown in Hardin County.

The average monthly precipitation for November was 0.88 in., resulting in a monthly deficit of 1.76 in. for the state as a whole and 2.25 in. for the southern third. This deficiency is emphasized in Fig. 2g, which shows the –10-in. line extending from Clark

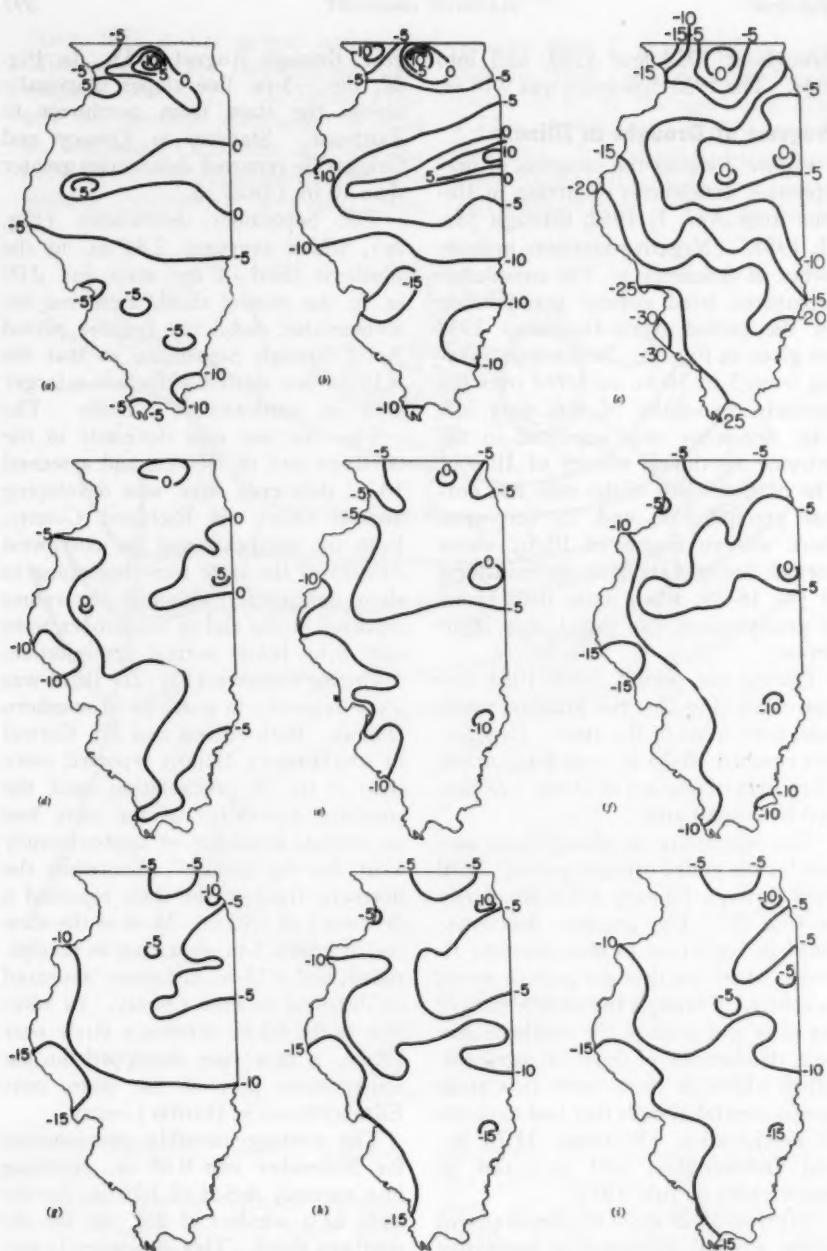


Fig. 2. Inches of Rainfall Deficiency, April 1952-January 1954

Key: a—Apr.-Dec. '52; b—Apr. '52-Aug. '53; c—Apr. '52-Jan. '54; d—Apr.-Aug. '53; e—Apr.-Sep. '53; f—Apr.-Oct. '53; g—Apr.-Nov. '53; h—Apr.-Dec. '53; i—Apr. '53-Jan. '54.

County in the east to Rock Island County in the northwest. The -15-in. line now included parts of Adams and Greene Counties, and an area in northern Cook County had a 10-in. deficiency.

Figure 2h, for the period April-December 1953, shows an enlarged area of 15-in. deficiency. Little change took place in January 1954, as indicated by Fig. 2i. The whole southern half of Illinois had a deficiency of 10 in. or more for the period April 1953-January 1954.

Effects of Drought

Long-term records at seven rain-gaging stations in the drought region reveal that the April 1953-January 1954 drought is the worst in 48 years. Preliminary estimates indicate that a drought of this type can be expected to occur during the April-January period only once in 102 years.

Stream flow for December in the Sangamon River at Monticello was next to the lowest ever recorded in the 44 years this station has been operating. The records for the Big Muddy River in Franklin County showed the flow for December to be the lowest in 39 years.

The effects of a rainfall deficiency in one year may carry over into the next year or even longer. It is obvious that a reservoir which has been drawn down during a dry season, and which has not been filled during an intervening wet season, has less storage the following year. This applies to underground storage as well, but there the effect is not so easily evaluated.

In the area in which the rainfall deficiency was more than 10 in. during April-December 1953, there are an estimated 302 public water supply systems. In this region, roughly the southern half of the state, a very high

proportion of the sources of supply are surface waters. With the exception of cities in the northeastern portion of this zone and those adjacent to alluvial deposits along major streams, communities using ground water sources have frequently had difficulty in developing large-capacity systems. As a result, many impounding-reservoir sources, side-channel reservoirs, and direct intakes from channel dams on large streams are in use.

As the drought progressed, the earliest difficulties encountered were those attributable to deficient flows in streams from which water was taken at channel dams. By October 1953 four communities in the drought region had been forced to resort to emergency measures. In November four more found their regular supplies inadequate, and, by Mar. 1, 1954, the total had reached sixteen. Three had been using ground water, and the rest surface water.

In addition, there were 28 cities whose supplies had become perilously short (Fig. 3). Of these, eight used ground water and 20 surface water. None of the former was faced with complete exhaustion of the supply, although several were on reduced rations. Of the 20 surface water communities, fifteen had less than 3 months' supply on hand and five had less than 4 months' on hand on Feb. 1, 1954.

Emergency Measures

Since April 1953 five communities (Vienna, Pittsfield, Bunker Hill, Greenfield, and Marissa) have found it necessary to haul water from other municipalities. The price charged for such water at the source ranged from 50 cents to \$1.00 per 1,000 gal, and the hauling costs varied from \$2.00 to \$6.00, depending on the distance. The

water was usually hauled to the municipal water works, dumped into the clear well, and pumped through the regular distribution system. Several communities have given thought to the complete cessation of piped water service, but there is no record that any has taken this step, which would eliminate fire protection.

To meet the cost of hauling the water, rates of \$3.00-\$7.00 per 1,000 gal were instituted. One community adopted the interesting procedure of charging \$4.00 for the first 1,000 gal per month per service, \$5.00 for the second 1,000, and \$6.00 for the third, in an effort to discourage waste.

Water was hauled in tank trucks normally used for transporting gasoline. Inasmuch as the density of gasoline is approximately 75 per cent that of water, it was not possible to fill the tank trucks completely without exceeding highway load limits. At Pittsfield, the entire supply, 100,000 gpd, was hauled by trucks 21 miles from Louisiana, Mo.

A number of the drought-stricken communities tapped new surface sources. Some very ingenious schemes were used in the transmission of this water. At Effingham, for example, an abandoned twin 8-in. oil pipeline was pressed into service. Water was pumped into the line from the Embarrass River, 18 miles away. Approximately 1,800 ft of this pipe had previously been removed, and it was temporarily replaced by a 4-in. line, with the result that pumping pressures as high as 500 psi were necessary at times. The problem was further complicated by the fact that the pipelines were originally full of crude oil, which had to be removed and disposed of before the water from the new source could be used. Effingham has an open

pump suction well into which the oil was discharged for burning.

Through a community effort, completely locally financed and manned by volunteers, Astoria built a 3-mile pipeline to a lake owned by a religious or-

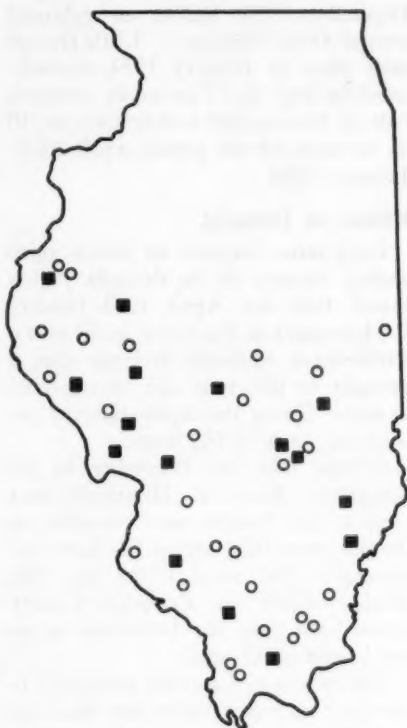


Fig. 3. Effect of Drought, 1953-54

- Localities using emergency sources of supply
- Localities threatened with water shortage.

ganization. Rights to use the lake as a source of supply for 2 years were secured. With an emergency pipeline, Albion tapped a shale pit. Kincaid and Olney rented privately owned lakes. Harrisburg and Elkhart tapped strip

mines. Vienna made use of a railroad water supply reservoir.

Also through a community effort, Marissa built dams to impound two new lakes, but these were still dry on Mar. 1, 1954. When its impounding reservoir gave out, Marissa obtained water from two privately owned lakes in the vicinity by discharging it down creek beds tributary to Mud Creek, where the city has a low-lift pumping station.

Carthage drilled a well to supplement the water supply from the municipal lake. Well construction efforts at Pittsfield have not succeeded to date. Additional wells were constructed by Jerseyville, which had previously relied principally on springs.

Jacksonville and Mattoon had maintained standby sand and gravel wells that formerly furnished water for the municipality. These were placed in service as the drought progressed, and considerably reduced the demand on the municipal impounding reservoirs. It is anticipated that the wells at these two communities may furnish the entire supply for restricted use, if the reservoirs become completely empty. In both cities, additional well construction was undertaken to develop the fields already existing.

Arcola and Christopher have started water main leak location programs, which have reduced the pumpage of water 40 per cent or more, thus making the present source of supply adequate for the immediate future. Many communities have put restrictions on water use, such as forbidding car washing, lawn sprinkling, and distribution of water by tank trucks to rural areas. Effective publicity campaigns have encouraged reduction in use within homes and industries. At Johnston City, such a campaign decreased consumption ap-

proximately 40 per cent below the January 1953 figure. Most communities are reluctant to cut off the distribution of water through tank trucks to farmers in their trading areas, but a number of cities have been forced to do so because of the seriousness of the situation.

Causes of Shortages

Of the 302 municipal water systems in the drought area, 95 per cent were equipped to meet the extreme conditions experienced. Of the sixteen communities that were not, nine had had difficulties in previous years and were aware of the limitations of their sources. This leaves only seven communities whose shortages were unexpected, solely because the drought was an extremely unusual occurrence. Ninety-eight per cent of the communities in the drought area met the situation satisfactorily. It therefore appears that the engineering design procedures used in planning Illinois public water supply systems were generally adequate to withstand this extreme drought.

Despite the availability of good engineering techniques, 44 Illinois cities either suffered water shortages or were threatened by them. The reasons for this condition are numerous, but they can be grouped into four classes: growth in demand, management deficiencies, municipal finance problems, and lack of information on water resources.

In every field of water use, trends toward increases are evident. Good management can and does foresee the threat of drought and rising demand. Population growth, industrial development, and steadily increasing per capita use are some of the factors responsible for supply problems. A number of communities have overtaxed the ca-

capacity of their systems by contracting to furnish water to other towns.

Sometimes the only practicable solutions to water problems are so expensive that the financing power of the community will not permit their consideration. The cities affected may be unable to issue the necessary bonds, or the costs may be so high that the required rate increases are deemed intolerable. Many of the state's water works systems were built at a cost of approximately \$30 per capita. Today the average cost of building a system is \$150 per capita. Water rates are often too low, and, what is more serious, water works income is frequently diverted to general corporate use to relieve other municipal fiscal problems.

Inadequacies in engineering design have, in some instances, resulted in systems that were not capable of meeting extreme dry-weather conditions. These deficiencies may be attributed to a number of factors, among which are reservoir silting; absence of data on rainfall, stream flow, or evaporation; and lack of leadership in developing more precise and reliable methods of engineering analysis.

More and better information on water resources is needed. Rainfall data deficiencies result from insufficient measurements and from difficulties in processing the data already collected. The situation demands an expanded, more detailed rainfall measurement program, as well as the utilization of modern punchcard transcription of all the old records. These requirements cannot be met under the state's present program.

Arrangements for obtaining stream flow data now include too few meas-

uring points on typical streams. This condition could be corrected by increasing the present stream-gaging program with federal cooperation, but action is needed to establish cooperative programs between the state and the cities that have surface water reservoirs. Personnel are not available, however, at either state or city level, to correlate and analyze the data collected.

The analysis of stream flow data is essential to the solution of many problems. Such data are employed by consulting engineers, but they look to the state for leadership in analysis and effective use of the data in design. State personnel have not been available to do this job.

Acknowledgment

Acknowledgment is due to several members of the staff of the State Water Survey, Urbana, Ill. The discussion of the cause of the drought was prepared by Glenn Stout, Head, Meteorology Subdiv., and Floyd Huff, Meteorologist, who also assisted in analyzing the rainfall records. H. E. Hudson Jr., Head, Eng. Subdiv., supervised the field work and the assembling of the data; he was assisted by W. J. Roberts, Assoc. Engr.; E. G. Jones, Assoc. Engr.; J. B. Stall, Asst. Engr.; and Jack Bruin, Asst. Engr.

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Views on Watershed Control

A Symposium

A selection of papers on watershed control presented at various recent section meetings.

Eastern States—Edward S. Hopkins

A paper presented on Oct. 29, 1953, at the Chesapeake Section Meeting, Wilmington, Del., by Edward S. Hopkins, Prin. Assoc. Engr., Bureau of Water Supply, Baltimore, Md.

THE ideal source for a public water supply is an isolated, forested watershed without habitation and with all recreational use prohibited. It is obvious that, with automobile transportation available to everyone, this situation is impossible to attain. It should be recognized that there are several types of watersheds, although the particular water utility is interested only in the one under its control. Up to the present, no concerted effort has been made to develop the watershed picture in its entirety.

Small cities and towns rely mainly on well supplies. Of all American cities with more than 100,000 population, approximately 20 per cent also depend upon these sources, while the remaining 80 per cent are about equally divided between those cities utilizing impounding reservoirs and those taking water from the Great Lakes or from large rivers.

Cities located on large rivers that serve as their source of supply do not have direct control over their watersheds and must rely on the various state health departments to abate nuisances and eliminate industrial wastes. These conditions apply to such typical rivers as the Potomac, Susquehanna, Ohio, Missouri, and Mississippi.

The Great Lakes cities are in a different category. There is a large volume of water in the lakes, and pollution from domestic sewers and industrial wastes enters at the shoreline. To overcome these hazards, the intakes or cribs have been extended several miles offshore. Control over the wastes discharged at the shoreline is vested in the health departments of the states bordering on the lakes. In these instances, the water utilities and health departments maintain close cooperation in pollution control.

Impounded small rivers flowing through sparsely inhabited woodland or farming country with small villages are found in many sections of the United States. The responsibility for the sanitation of such watersheds, although vested in the various state health departments, is usually delegated to local health agencies, with which the water departments must cooperate.

It is apparent that watershed sanitation will differ for various types of supply sources. It has been pointed out that the Great Lakes cities and those on large rivers cannot directly control pollution on their watersheds. Water from large rivers is grossly contaminated, but, with modern purification processes and constant vigi-

lance, these cities produce drinking water that conforms to modern standards of safety and palatability and they have extremely low waterborne-disease death rates. It must not be inferred, however, that stream pollution control should be neglected; on the contrary, it should be enforced as well as local conditions permit.

Stream Pollution Control

The primary use of a river is for water supply, and the object of stream pollution control is to minimize the density of pathogenic organisms and industrial wastes in the stream, so that the purification facilities will not be overburdened. Stream pollution control is of vital importance as it is the only watershed sanitation measure available for large rivers.

No hard and fast rule determines what is and what is not pollution. In many instances, the criteria have been the protection of aquatic life and the provision of a water supply as free from contamination as possible. It is now known that "much of stream life [degradation], formerly attributed to pollutants, is really occurring because our streams and lakes are growing old, and are changing in nature and aquatic population with changes in their environment" (1).

Many years ago the Pennsylvania Sanitary Water Board proposed that stream pollution control should be governed by the classification of the stream according to its usage. It is now recognized that this fundamental concept is correct, and that fixed standards, as determined by chemical and biological constants, cannot be established or enforced for an entire river. Usage in relation to pollution factors of separate sections or zones must be the basis for

pollution control, and procedures that best fit local needs should be instituted. In the last analysis, the object of stream pollution control is to protect the existing clean waters and to improve the unclean and contaminated waters, so that they may be utilized by the most people for the greatest number of purposes. It is believed, however, that water of a purity equal to that of an impounding reservoir should be the goal where potable supplies are involved.

The author concurs in a recent statement by Hedgepeth (1) concerning the underlying philosophy of stream pollution abatement:

The case being made for stream pollution control from a public health standpoint has little scientific evidence in its support and, with the exception of the threat to public water supplies, is being discounted by professional workers in this field. Our polluted streams flow through healthy communities. Morbidity statistics do not support the adoption of stream pollution abatement measures as a means of improving public health. The case for these measures must today be made on the foundation of what is considered to be good public health practice and common decency rather than on statistical evidence. The epidemiological evidence in support of the much publicized threat of stream pollution to public health, other than to public water supply, is lacking.

Even the threat to public water supplies is not as watertight a case as many of us would like to have it. Some of our most polluted streams—from sewage and industrial effluents—are serving as sources of public water supply for communities which enjoy extremely low waterborne-disease death rates. A [residuum] of odor remindful of past pollution is often present, but the bad history is not manifested in presently measurable evidence of impairment of public health. This is

but another way of saying that the art and science of water purification [have] kept pace with the increasing polluttional load on the streams.

With modern purification, it becomes evident that, for an impounded river supply, a virgin woodland watershed is archaic. Unless storage and chlorination are the only purification processes used, this type of watershed may be considered a relic of the past. Raw water with as little pollution as practicable should, however, be obtained. The courts have usually recognized the need for a utility to protect its watershed even though a limitation of private property rights results. On this type of watershed, protective practices are limited to the control of the area surrounding the reservoir and to periodic inspection of properties upstream. Authority to enter private property in order to abate a nuisance and enforce regulations is usually vested in the water supply agency.

There should be some economic balance between expenditures for purification and those for watershed sanitation, when both are practiced. If a modern treatment plant is part of the system, less money should be spent on watershed sanitation than if reliance is placed upon reservoir storage and subsequent chlorination of the effluent. It must not be forgotten, however, that the most efficient watershed control measures cannot replace purification.

Some large cities have given up using a river water with complete purification in favor of impounded storage with sedimentation and chlorination. In 1940 Harrisburg, Pa., abandoned the polluted Susquehanna River for an impounded upland source (2). This action was taken despite the fact that

operation of the purification plant was satisfactory. The change was necessitated by frequent floods at the former plant.

New York City Practice

Sanitary control of a watershed is usually accomplished by an inspection service under the jurisdiction of the water department in cooperation with local and state health agencies. Protection practiced by the New York City Dept. of Water Supply, Gas, and Electricity is a classic example of the control of impounding-reservoir watershed areas when storage and chlorination are the only purification processes. As learned by the author during a recent inspection trip, the commissioner of the department is responsible for keeping the supply "pure and wholesome and free from contamination and pollution." Departmental regulations are enforced to prevent the pollution of any reservoir or tributary stream by sewage from private homes, institutions, and communities. Conforming with its mandate, this department has established a comprehensive inspection system covering sewage disposal and nuisance abatement on the Croton and Catskill watersheds; it also operates many sewage treatment plants for the towns and villages located therein.

The measures employed include sand filtration and chlorination of the effluent, with primary purification by either septic tank or Imhoff treatment. Another feature of this system is the incorporation in the village plants of tanks for the collection of scavenger wastes hauled from domestic septic tanks, cesspools, and privies. This arrangement prevents clandestine disposal in undesirable places. The

wastes are subsequently discharged into the inlet sewage lines at the plant and treated along with the sewage.

A standard of coliform-organism density equal to that of the water in the reservoir is required of domestic sewage plant effluents discharged into the reservoir or a contributing stream.

Completely Treated Water

Where the water from impounded river sources adjacent to urban areas is given complete treatment, the watershed sanitation problem presents a different aspect. It is obvious that the urban areas will produce a certain amount of industrial wastes and sewage. Plans for waste and sewage treatment plants must be approved by the state health department, in collaboration with the water supply agency, prior to permitting an industry to establish itself in the community. When existing communities are present on a newly acquired watershed, their industrial activity must be surveyed and sewage treatment plants, together with industrial waste disposal works, must be installed promptly. Supervision of plant operation should be the responsibility of both agencies.

The criteria for industrial wastes are usually established by the stream pollution agency in each state. In general, basic consideration is given to toxicity, quantity of solids, depletion of oxygen in the stream, acidity, color, and materials causing tastes and odors. It is evident that the standards should vary with the characteristics of the stream receiving the industrial waste. It is frequently necessary for such wastes to be completely treated, using biofiltration or trickling filters, with postchlorination of the effluent.

One of the most outstanding cooperative programs for the protection of

a watershed was developed by the Maryland Dept. of Health, the Baltimore Bureau of Water Supply, Congoleum-Nairn, Inc., and the Schenley Distilling Co., for the treatment of industrial wastes from plants at Cedarhurst, Md. These companies spent approximately \$900,000 for treatment works, including lagoons, biofiltration, and postchlorination facilities. The details of these installations have previously been described (3).

Sewage Plants

Where urban settlements are adjacent to reservoirs or contributing streams within a short distance from the reservoir, every effort should be made to convert existing septic tanks, cesspools, and privies to a community sewage plant. With the growing increase in private water supply systems and subsequent installation of waterborne sewage disposal, it will only be a matter of time before the subsoil in these communities becomes so saturated with sewage that percolation into a reservoir or contributing stream without the benefit of filtration through the ground is inevitable.

The bacterial density of effluents from village sewage plants should equal that of the contributing stream or reservoir into which they are discharged. This discharge should not be closer than 5,000 ft from a reservoir intake. To obtain the desired purity, it is necessary to install complete treatment, including trickling filters or biofiltration and postchlorination. It is not believed that secondary sand filtration is needed when complete purification is given to the water prior to delivery to the consumers.

Village sewage treatment plants should handle scavenger wastes collected from various sources on the

watershed. The operation of such plants should be under the supervision of both the water supply agency and the health authorities. This responsibility is inherent because the courts have usually recognized the necessity for water supply agencies to protect their watersheds.

It would be very desirable if sewage treatment works were made mandatory for all towns and villages adjacent to reservoirs or located a limited distance upstream on contributing watercourses. It would undoubtedly be difficult to obtain legislative action for this purpose in many areas, but, if it were shown to be in the best interest of the community and if substantial financial contributions were made by the water supply agency, the installation of such projects could be accomplished.

Institutional sewage disposal systems are normally a responsibility of the local or state health departments. Supervision of their operation on watersheds should be a responsibility of the health agency and the water department. Inspection service, when treatment is given, should be kept to a minimum, with visits not more frequent than once a week. In most instances, monthly visits would be satisfactory, as the purification process can be depended upon to deliver a potable water to consumers.

Recreational Activity

The subject of recreational activity on the watershed is controversial. Many restrictions are being removed in all sections of the country. Fishing from boats, shore, and bridges is being constantly practiced, a trend that is obviously fostered by sportsmen's organizations. It must be conceded that daily bacterial testing of the 20-bil gal Loch Raven Reservoir at Baltimore

has failed to indicate any signs of contamination owing to these activities. It is believed that, if recreational activities are under the direct supervision of the water department, undue sanitary hazards can be controlled, and the quality of the raw water delivered to the purification plant will not be seriously impaired.

When control is vested in other agencies, there is inherent danger to the supply, especially if chlorination is the only purification measure. This point is illustrated by the waterborne intestinal-disease outbreak at Concord, N.H., in 1951 (4).

Conclusion

It is apparent that the modern trend in water purification is to rely more and more on the efficient operation of the treatment plant rather than to develop an elaborate inspection system for the watershed of impounding reservoirs. When sedimentation in large reservoirs and chlorination are the only treatment measures used, the development of an extensive watershed inspection service is warranted. If the source of supply is a large river or one of the Great Lakes, control of the watersheds or of the boundary lands must be exercised by the state health departments. The use of such water without complete treatment is not justified.

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Washington Suburban Sanitary District—John M. Jester

A paper presented on Oct. 29, 1953, at the Chesapeake Section Meeting, Wilmington, Del., by John M. Jester, Div. Engr., Maint. & Operation Div., Washington Suburban San. Com., Hyattsville, Md.

This paper will briefly describe what is being done on the watershed of the Washington Suburban Sanitary Commission's Triadelphia Lake. This lake, formed when Brighton Dam was built across the Patuxent River in 1943, has a designed storage capacity of 6.5 bil gal. The catchment area above Brighton Dam comprises 52,000 acres, approximately four-fifths of which is devoted to farming and cattle raising. The remaining fifth consists mainly of woodland. Approximately 67 watercourses contribute to the lake, and the drainage area is traversed by public roads, many of them unimproved.

The chief problem in this watershed is silt pollution caused by the erosion of farmlands, gullies, stream banks, and, especially, roadsides. As the commission owns only a relatively small portion of the land within the drainage area, it was necessary to establish a long-range erosion control program with the cooperation of the landowners involved. To this end, the commission, since 1947, when a survey of the watershed was completed, has been working with officials of the conservation districts and counties involved, as well as the agricultural extension service of the University of Maryland and such Maryland state agencies as the Soil Conservation Committee, the Dept. of State Forests and Parks, the Roads Commission, the Game and Inland Fish Commission, and the Dept. of Research and Education. The Soil Conservation Service of the US Dept. of Agriculture is also cooperating.

In order to control erosion and excess runoff on the farmlands in the

watershed, it is necessary for the soil conservationist first to convince the landowners of the value of a program for sound land usage. Then land usage maps must be prepared and agreements made between the landowners and the county soil conservation districts. Thereafter the local conservationist must render such technical assistance as may be required by the landowners in rearranging fields, laying out contours, building fish ponds, constructing drainage ditches for the reclamation of bottom lands, and planning diversions and terraces. The conservationist must continue to maintain close contact with the landowners, both personally and at conservation meetings, in order to advise them on crop and grazing rotation and to watch the progress and effectiveness of the program.

The stream bank program involves the removal of such stream bed obstructions as fallen trees and heavy brush, the straightening of stream beds, and the sloping, planting, and riprapping of stream banks where required. Assistance in the form of labor and equipment is sometimes furnished.

Roadside erosion has been a major problem in this area. At present the two counties in which the majority of the roads are located have been cooperating to the extent of sloping and grading the road banks in the area as rapidly as finances and time permit. After being sloped, the road banks are mulched, fertilized, and seeded, the funds being furnished by the Washington Suburban Sanitary Commission and the work supervised by the county

soil conservation districts. The Maryland Roads Commission is also taking a very active part by sloping and seeding road banks in connection with its road-widening projects.

The benefits of the conservation program are indicated by a recent report from the Maryland Soil Conservation Committee, which states that considerable improvement in the vegetative growth along the stream banks has resulted from the fact that a decreasing amount of flood water, silt, and gravel is coming in from farmlands and roadways. Strip cropping is being practiced on 2,300 acres, and contour cultivation on 2,400 acres. Approximately 2,400 acres of pasture has been improved, and 52,000 sq yd of road bank has been seeded and mulched. In addition, 14,000 ft of hedgerow has been established, using multiflora rose and lespedeza. It is estimated that the conversions in land use will reduce erosion from soil movement by approximately two-thirds of the current rate.

In order to carry out this program, the Washington Suburban Sanitary Commission has been making cash contributions to the Maryland Soil Conservation Committee for the purchase of vehicles, farm implements, seed, fertilizer, and mulching material. A tree planter is also available to the land-

owners for use in reforestation. The equipment furnished by the commission is of a type that is not generally needed for ordinary farming. Moreover, the commission has approximately 20 acres of land planted in lespedeza, the cuttings from which are used for mulching, and approximately 100,000 multiflora rose plants are raised in its nursery each year for distribution on the watershed to establish live fence rows. Space does not permit a description of other commission projects involving watershed recreation, fishing, reforestation, and game preservation.

Conclusion

A very good start has been made toward reducing soil erosion to a minimum on this watershed. It is necessary to attend only a few of the meetings held by the landowners and conservation authorities in this area, to feel the enthusiasm they have for conservation measures that will prevent the loss of topsoil, reduce water runoff, and produce better pastures and more abundant crops. In view of the enormous sums involved in the construction of impounding reservoirs, the ever increasing demand for water, and the fact that many of these reservoirs are irreplaceable, every possible effort should be made to extend their useful life.

San Diego—Roy E. Dodson Jr.

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Roy E. Dodson Jr., San. Engr., Water Dept., San Diego, Calif.

From the standpoint of water quality alone, the ideal in watershed control might include outright ownership of the entire watershed by the utility, absolute prohibition of trespassing and commercial or recreational use of the

land or reservoir waters, and continuous policing to enforce these requirements. Such control, however desirable, is no longer practical, except for very small or very remote watersheds. As land uses increase, watershed con-

trol must slowly conform to the more general needs of the area, its people, and their total economy. Water works officials must determine how strongly they should resist the encroachment of other land uses on the watersheds.

It may seem absurd to theorize on this subject when one thinks of the vast watersheds where public water supply may be only a minor one of many uses, where sewage disposal is a primary use, or where watershed control simply does not exist. Fortunately, in the far western United States, civilization has had more room in which to expand, and the watersheds are not yet altogether taken up by other uses. It may be well, then, to theorize a bit, if it will help to plan a more orderly transition from the "wide-open spaces" to the complete population saturation that will ultimately face this region. The San Diego, Calif., watersheds, which are approximately halfway between these extremes, will serve as a good example for the purposes of this discussion.

San Diego Watersheds

San Diego's water supply depends primarily upon a system of impounding reservoirs on the western slope of the coast range of mountains. The total area above the various dams is 954 sq miles, of which the city owns only 80. Approximately 90 per cent of the entire watershed area is steep and rocky, and much of it is included in Cleveland National Forest. Aside from a few cabin settlements, the main use of this country is for sparse cattle grazing, hunting, and hiking. It represents a very early stage in the evolution of a large watershed area.

The remaining 10 per cent of the watershed area consists of scattered

valleys used for light farming and livestock grazing, with some small villages. It is estimated that, on the average, there are five persons and sixteen head of cattle per square mile of watershed area. The concentration of cattle may run as high as 1,000 head per square mile along the few stream beds.

There are no perennial streams in the entire area, except for a few minor spring-fed creeks that disappear near their sources. In summer the stock is watered from wells or, if the owner is bold enough, from the impounded reservoir waters. In some of the isolated areas, such trespassing has been most difficult to control.

San Diego owns a total of approximately 15,000 acres immediately adjoining the various impounding reservoirs. Of this area, approximately 9,000 acres is leased for farming and grazing. The city retains an agricultural consultant to advise on the best uses of this land. Privately owned lands near the reservoirs are now utilized for grazing or light farming. How long such use will continue is a serious question.

On all of the 954 sq miles of watershed area serving the city, there is no industry as yet, except for a few small lumber mills and mines occasionally operating in the upper reaches. Towns and resorts are few, but they are steadily growing.

In the lower valley areas, subdivision activity has become an immediate problem. In order to forestall some hazardous and embarrassing situations, the water and county health departments are making a joint effort to have a protective agricultural zone established by the county government. Such a zone would safeguard the shores of all reservoirs impounding domestic water

supplies against hazardous encroachment. This zoning provision would be invoked wherever it might be financially impossible for the water utility to purchase all surrounding lands. The legal and political difficulties involved in this policy have not yet been completely solved.

It may be seen that the valleys are in a much later stage of land use than the steep, rocky uplands that make up the bulk of the watershed. The valley regions will naturally attain their ultimate development, and thus become a serious threat, long before the uplands, unless some artificial barrier, such as land condemnation or zoning, is established.

Recreational Use

The first step in creating the far-flung system of impounding reservoirs now serving San Diego was taken in 1895 by a private land and water company, which built Lower Otay Dam. The resulting impounded water irrigated lands to the south of the city. Homes were still supplied from wells and cisterns. The land company officials, their friends, and neighboring farmers immediately began to use the lake for fishing and duck hunting. Because of the nature of the water supply and its end use, little attention was paid to sanitary facilities or to water quality.

By 1906 the company was selling water wholesale to San Diego for domestic distribution, and had installed a pressure filter plant nearby. Because the potable supply was filtered, there was no great objection to the continued use of Lower Otay Reservoir for recreation on an unofficial basis.

The city purchased the Lower Otay system in 1913, and, in answer to many

requests, adopted an official plan for fishing and hunting on the reservoir, with set fees. There was little concern over water quality, but some rudimentary sanitary facilities were provided. The city's water quality consultants advised strongly against this recreational use, but the popular clamor for a freshwater fishing and duck-hunting spot in arid Southern California prevailed.

The present practice of reservoir recreation in San Diego, then, had its official beginning 40 years ago, and unofficially several years before that. Each succeeding city council sanctioned the practice, and certain other reservoirs were opened to recreation as they were developed. Sanitary control and treatment processes have, of course, steadily improved through the years.

The present impounding system consists of eleven reservoirs, varying in capacity from 300 to 116,000 acre-ft, with a total capacity of 429,000 acre-ft. The three smallest reservoirs are regulative, and only one of these—owned by another utility, which uses it jointly with San Diego—is open to recreation.

Of the eight strictly impounding reservoirs, six have been open at one time or another for fishing and hunting. Another, the largest unit in the San Diego system, has never been opened to recreational use. Joint use of this reservoir by outside areas served with unfiltered water has complicated recreational development. The eighth is not yet completed.

Reservoir recreation stations are opened and closed depending upon the water stage, the fish population, and the net income from the individual stations. They are planned and operated in consultation with an advisory recreation committee composed of leading sportsmen, and are under the super-

vision of the county and state health departments. At terminal reservoirs, recreational use is strictly prohibited for at least 1,500 ft upstream from the outlet works.

Toilet facilities in rural areas never have been completely satisfactory, and San Diego's reservoir stations have been no exception. Until recently can type toilets were used almost everywhere, and there was always a certain amount of complaint because of odors and flies. Lately flush toilets have been installed in those high-use areas where water supplies are available and where subsurface disposal is safe and practical.

In high-use areas not meeting these requirements, pump-out toilets are now standard equipment. The contents are hauled to the city for disposal in the sewers. In isolated parts along each shoreline, can type toilets are still placed every 1,000–2,000 ft and are serviced by maintenance crews. The contents are burned in incinerator pits, along with camp trash.

Fish-cleaning facilities are provided at most stations. Sink wastes pass through grease traps to subsurface tile fields. Solid scraps are burned in screened incinerator pits, which can be used only with the permission of the forest service. Oil is employed to discourage flies and to promote burning.

Limited overnight camping is permitted at four reservoirs. Tent and trailer sites are provided, with running water and electricity. The only heavy camping is at Morena Reservoir, which happens to be the most distant from the city but the closest to Imperial Valley. Located at an elevation of 3,000 ft above sea level and blessed with a cool summer breeze, this is a popular spot in the summer time, whether fishing is good or bad.

Fees are charged by the water department for most activities at the various reservoirs. The fishing or hunting fee is \$1.00 per day for each person over 16 years of age. Boats owned and maintained by the water department are rented at \$2.00 per day. The camping fee is \$1.00 per night per car or trailer, although picnicking is free. Swimming and sailboating are prohibited at all reservoirs. At each station there is a concessionaire, chosen by competitive bidding, who is responsible for collecting fees and issuing tickets. He is also permitted to rent outboard motors and tackle, and to sell bait, lunches, and soft drinks.

The enforcement of sanitary regulations and state game laws is carried on by keepers and their staffs stationed at each of the reservoirs, by a roving city patrolman, and by state fish and game wardens. These officers find relatively few violators, partly because the courts deal rather sternly with those that are brought in. It should be emphasized that poachers and trespassers in closed areas are as much of a problem as are the sportsmen in legally open areas. It is believed that, if all of San Diego's reservoirs were suddenly to be closed to all recreational use, the total number of law violators would decrease little, if at all.

Complaints about the present reservoir recreation program are very few. There never has been the slightest evidence of public demand to discontinue it. An occasional call or letter will refer to some overlooked litter, but such complainants seem to be more worried about losing their fishing privileges than about water pollution. Complaints of unsanitary conditions due to recreational activities are outnumbered ten to one by complaints about straying cattle.

In an overall consideration of land use as it affects water quality, it is doubtful whether reservoir recreation is of great significance. If it is believed, however, that surface water quality should not be subject to compromise, reservoir recreation seems to assume a much greater importance.

At the present stage in the evolution of San Diego's watershed, it is evident that such uses as recreation, either on the impounded waters themselves or around the shores, entail far fewer hazards than do the conditions in highly congested industrial or residential sections. Compared with the large volumes of waterborne sewage or industrial wastes from areas of the latter type, contamination from the recreation camp, with its small and isolated sewage problems, seems quite innocuous.

Future Watershed Uses

Because of the tremendous rate of development in the West, and because of the demand for suburban homes, it appears that many watersheds are about to leave the early evolutionary phase and enter the critical "middle stage" of competitive land use. At the same time, health officials, water works men, and the public are all demanding higher standards of water quality. Better water treatment is the obvious answer. In line with this viewpoint, San Diego already has provided filtration for all of its water supplies and plans further improvements in the coming years.

Factor of Aesthetics

The aesthetic factor in water quality usually has been foremost in forcing

the adoption of better water treatment. In fact, this consideration will probably lead to the adoption of complete water treatment long before any watershed uses actually create a serious water quality hazard. From then on, it will be a matter of reasonable compromise between aesthetic perfection and economic land use.

A question naturally arises concerning the great disparity in cost between simple chlorination and complete treatment. It is conceivable that a town whose watersheds are being jeopardized may feel that it cannot afford complete treatment. Usually, however, widespread watershed use means a greatly augmented economy in the area. Thus, a town may become able to afford better water treatment because of the very development that threatens to degrade the watershed.

Conclusion

It was suggested earlier that water works officials must determine how strongly to resist the encroachment of other land uses on watersheds. The author believes that the threat of encroachment should be used as a lever to help hurry along the day of better treatment facilities. Water utilities should, of course, resist encroachment of a hazardous sort until adequate facilities for treatment are available. The time is certainly near, however, when the fiction that a "sterile" watershed is the key to water quality will have to be abandoned. The modern water consumer expects water of high quality, either with or without controlled watersheds.

East Bay District—Gordon L. Lavery

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Gordon L. Lavery, Asst. San. Engr., East Bay Munic. Utility Dist., Oakland, Calif.

The author is engaged in watershed sanitation work for the East Bay Municipal Utility Dist., a water utility serving approximately 1,000,000 people who live within a 200-sq mile area extending along the east shore of San Francisco Bay in California. District water supplies are derived from surface sources and stored in five reservoirs. The watersheds for these reservoirs have the following areas, in square miles: Pardee, 575; San Pablo, 32; Upper San Leandro, 30; Chabot, 12; and Lafayette, 1. The district owns the land bordering all five reservoirs. The Pardee watershed is generally rough and granitic and is little populated. The other four watersheds are in grass-covered foothill country just east of the Oakland-Berkeley Hills.

As a result of the demand by local citizens that pure water brought by aqueduct from the mountains be kept pure while in local storage reservoirs, the East Bay Municipal Utility Dist. adopted a policy of preventing contamination and pollution of the public water supply and maintaining a program of sanitary control of watershed lands owned by the district and other lands contributing water to the district's storage reservoirs. District watershed lands not provided with adequate facilities for removal of sewage are withheld from sale or occupancy. Houses on watershed lands have been purchased by the district and closed to occupancy in a limited number of instances where a public sewage disposal system was impractical and adequate

correction of individual systems was not possible. Controlled cattle grazing is permitted.

Control Program

Of the five watersheds, only Lafayette is not inhabited. On the other four watersheds, there are approximately 10,000 persons, settled mainly in residential communities. During World War II, and thereafter, portions of the Upper San Leandro and the San Pablo watersheds, previously populated by only a few summer homeowners, were in great demand as year-round residential property. Septic tank and tile drain leaching systems constituted the only available waste disposal method for the homes which were built by the hundreds. Because of the native adobe soil and a ground water table that was high in winter, septic tanks would not operate effectively throughout the year. As a result, the utility district became instrumental in the formation of a sanitary district whose purpose was to remove the sewage from the watersheds. The sanitary district embraced most of the homes that had been built, but excluded some because of topography or objections by the residents.

A shortage of trained manpower made it impossible for the utility district to exercise full-time engineering control of the watersheds until September 1951. In that month a three-point plan for reducing the magnitude of surface contamination by sewage was laid down: [1] to secure connection to

sewers of all the homes within local improvement districts (these districts are areas within a sanitary district organized to provide themselves with sewers); [2] to foster the formation of new local improvement districts where sufficient numbers of homes exist in a locality within a sanitary district; and [3] to annex to sanitary districts the developed areas originally outside them and encourage the formation of local improvement districts in such areas.

Meetings were held with local health officers and others concerned with public health, in order to acquaint them with the policy of the utility district and to coordinate the activities of the public bodies involved in the protection of the water supply. Attractive signs requesting the public to help protect the water supply were installed along roads on all the watersheds.

In practice, the three-point plan has proved effective. On the San Pablo, Upper San Leandro, and Chabot watersheds, the Central Contra Costa and Castro Valley sanitary districts have cooperated in securing residential connections to sewers, and the local health departments have strictly limited the number of new septic tanks installed on watershed lands.

The formation of new local improvement districts has been a problem, for homeowners in postwar subdivisions already carry a heavy financial burden and have little desire to bear the additional cost of installing sewers. It has taken the actual overflow of septic tanks to convince residents that sewers are not a luxury, but a necessity on which the health of their children and the future growth of their communities depend.

The inspection of individual septic tanks by utility district and health de-

partment sanitary personnel results in close contact with the public, to whom the advantages of sewers and the disadvantages of maintaining septic tanks are pointed out. This explanation prepares the way for future meetings of the property owners to organize local improvement districts.

At present most of the homes being built on the Upper San Leandro and San Pablo watersheds are sewerer immediately; only in good ground are septic tanks occasionally being installed. The denial of septic-tank permits because of poor soil conditions has resulted in inconvenience to some prospective home builders. In general, however, once the problems and the hazard to the public water supply are explained, the people join together to install approved community sewage disposal systems. In this manner, annexations to sanitary districts and the formation of local improvement districts are effected.

Recreational Use

Recreational use of watersheds and reservoirs has been a plague to most engineers who have had to control watersheds for domestic water supply reservoirs. Aside from residential areas, the only East Bay Municipal Utility Dist. watershed lands legally accessible to the public are the Redwood and Grass Valley regional parks, which are located on the Upper San Leandro and Chabot watersheds. Lands for both parks were sold by the utility district to the East Bay Regional Park Dist. under agreements containing strong sanitation control clauses. Even written agreements on watershed use, however, are not guarantees against contamination. Human nature being what

it is, constant inspection is the price of good watershed sanitation control.

Multiple use of utility district reservoirs is not permitted and has not been favored by health officials, nor are the reservoirs suitably endowed by nature to support recreation. Lake banks are steep and lake reaches are either narrow and tenuous or open and wind-swept—features tending to discourage sportsmen and endanger pleasure seekers.

Overnight camping by organized groups is permitted at one point in the Redwood Regional Park. Flush toilet facilities are available adjacent to this site. Ordinarily the park gate is closed at 10 PM each night. Equestrian and hiking trails traverse both parks. Horseback riding and hiking are at present the only activities permitted at the 3,000-acre Grass Valley Park, which was opened to the public only recently.

It has been calculated that, during storms, pathogenic bacteria could reach district filter plants within 8 hr. Inasmuch as filter plants depend on the fallible human element and on mechanical devices that do not always function, storage reservoirs must be kept as bacteriologically clean as possible. Improvements in treatment facilities do

not, by themselves, constitute a sufficient argument for multiple use of water supply reservoirs. Moreover, the fact that district filter plants are located in an active earthquake fault zone, as well as in an area exposed to potential war damage, calls for added caution.

Those not charged with the safety of water supplies often endanger them in a measure commensurate with their lack of responsibility. Supply sources should receive maximum protection to provide for emergencies in which filter plants are rendered inoperable. Only the responsible water works engineer should establish the standards of protection to be met.

Conclusion

The degree of watershed control to be employed by a utility depends on local public sentiment, local topographic and weather conditions, and the views of local engineering and health personnel. To set up a rigid yardstick for all watersheds is obviously impossible. Although the ideal of no watershed use is generally unattainable, the use that is permitted should be strictly controlled by those who are responsible for water supply quality.

New Mexico—Fred A. Thompson

A condensation of a paper presented on Sep. 22, 1953, at the Rocky Mountain Section Meeting, Santa Fe, N.M., by Fred A. Thompson, Director of Fisheries, State Dept. of Game & Fish, Santa Fe, N.M.

Those water consumers who object to the multiple use of reservoir lands cite the hazards of contamination, accidents, nuisances, and forest fires. In the author's opinion, these dangers can be overcome by proper water treatment

methods and adequate supervision of watershed areas. If such measures are taken, the benefits of recreational and other use of watersheds can be enjoyed without detriment to the potable-water supply.

Raton, N.M., is a good example of a city that furnishes pure and ample water to its residents while providing them with splendid fishing and picnicking facilities at its Lake Maloya reservoir. This 100-acre area is under rigid control. A caretaker is stationed at the lake throughout the year, and a special guard is employed during the summer. All persons are checked in and out of the lake area. In more than 3 years of operation, there have been no accidents, epidemics, or forest fires. Thousands of fish are caught annually, and people travel many miles to take advantage of the recreational opportunities afforded.

Elephant Butte Lake offers a further illustration of the benefits of multiple use. Originally an impoundment solely for irrigation and flood control, the lake soon began to attract fishermen in large numbers. As the popu-

larity of the area increased, other recreational activities developed, tourist accommodations were built, and a thriving community of several thousand persons grew up.

At Cimarron Canyon and Eagle Nest Lake, camping and picnic sites dot the entire area. During the summer this region caters to more than 400 people a day. Another New Mexico watershed heavily utilized for recreation is the Pecos River area above the town of Pecos.

The obvious public demand for additional recreation facilities will have to be recognized and met. Municipal reservoirs can safely and successfully be used for this purpose, within certain limitations. The difficulties that exist can be overcome by proper education of sportsmen, water consumers, and utility officials.



Need for Water Resources Conservation in Texas

By A. P. Rollins

A paper presented on Oct. 19, 1953, at the Southwest Section Meeting, Houston, Tex., by A. P. Rollins, Member, State Board of Water Engrs., Austin, Tex.

THE water problems of Texas are complicated by its large area and the great variety of physical conditions throughout the state. Its land area totals 263,644 sq miles or 168,732,160 acres. The longest straight-line distance in a general north-south direction is 801 miles, from the southern tip near Brownsville to the northwest corner of the Panhandle. The greatest east-west distance is 773 miles, from the Toledo bend of the Sabine River in Newton County to the extreme western point in El Paso County. The state varies in elevation from sea level to 8,751 ft on Guadalupe Mountain in Culberson County. The temperature ranges from a maximum of 112°F to a minimum of -16°F.

The mean annual rainfall varies from a maximum of 55 in. at the Texas-Louisiana line in Newton County to a minimum of 8 in. in El Paso. The isohyets (lines of equal rainfall) run generally north and south. It is widely assumed that the Gulf of Mexico has a decided effect upon rainfall in Texas, but the isohyets do not bear out this belief. In the eastern part of the state, the disposition of surface water is one of the problems. In the western part, strictest conservation is necessary. The decrease of 47 in. in average annual

rainfall from the eastern part of Texas to the western part means that, traveling west from the Sabine River, there is an average loss of approximately 1 in. of rainfall for each 17 miles.

In 1951 the ground water used in Texas totaled approximately 4,200,000 acre-ft. This tremendous quantity was employed to irrigate more than 2,500,000 acres of land, to supply 593 municipalities, and to furnish approximately 80 per cent of the rural, domestic, and stock-raising requirements. Water pumped for irrigation amounted to nearly 3,000,000 acre-ft. Of this amount, approximately 90 per cent was used on the Texas High Plains. An inventory of the use of ground water for public supply indicated that the 593 municipalities consumed approximately 350,000 acre-ft during 1950. In the first nine months of 1951, Houston, San Antonio, Lubbock, Plainview, and Amarillo showed pumpage figures that averaged 21 per cent more than in the corresponding months of 1950. The underground water supply is vast and varied. It is the supply most readily available to the people of Texas. Many of these underground reservoirs, however, are being depleted ten to twenty times faster than nature is replacing the supply. Some day

they will go dry unless the replacement of water is accelerated or the taking of water is reduced.

As of August 1952, the total average annual runoff in Texas amounted to 50,275,420 acre-ft (Table 1), a quantity sufficient to cover the entire land area of the state to a depth of 4 in. Unfortunately, droughts reduce the flow of the majority of the streams to zero or to quantities so small as to be useless. Continuous records up to 1948, prior to the construction of major reservoirs, revealed that all the

During the summer of 1952, with the exception of the Red and Sabine rivers, every stream in Texas ceased to flow. A dam was built across the Neches River at Beaumont to prevent salt water from reaching the pumping plants above the city. The water users on the lower Trinity found it necessary to construct a dam across that river near Anahuac, in order to prevent salt water intrusion at their pumping plants. The Brazos River had a 60-day period of no flow at the Juliff gaging station. The Lower Colorado River Authority

TABLE 1

Average Annual Runoff

Stream	Runoff acre-ft
Canadian R.	501,700
Red R.	8,875,000
Sulphur R.	2,211,000
Cypress Creek	1,605,000
Sabine R.	6,952,000
Neches R.	6,254,000
Trinity R.	5,922,000
San Jacinto R.	1,847,000
Brazos R.	5,723,000
Colorado R.	2,310,000
Lavaca R.	695,000
Guadalupe R.	1,872,000
Mission R.	84,100
Nueces R.	640,000
Rio Grande	4,783,000

streams in 72 counties east of the 100-deg meridian (the eastern border of the Panhandle) and in 69 counties west of that meridian had a zero or useless flow at times.

Although there is a mean annual available water supply of approximately 63,000,000 acre-ft, in 1951 the consumptive use was only 8,465,000 acre-ft, while the appropriations of record amounted to 34,818,725 acre-ft (Table 2). Thus, the consumptive use of water in 1951 was approximately 25 per cent of the amount appropriated.

TABLE 2

Texas Water Use, 1951

Purpose	Con- sumptive Use acre-ft	Granted Appro- priations acre-ft
Irrigation	4,343,080	9,691,641
Manufacturing and industrial	2,560,014	13,341,702
Municipal and domestic	573,476	3,182,255
Hydroelectric and flood control	*	8,544,359
Recreation	†	58,768
Losses from storage	988,760	
Total	8,465,330	34,818,725
Mean annual unused runoff	54,638,400	
Mean annual available water	63,103,730	

* Nonconsumptive use, 5,314,810; consumptive use, negligible.

† Negligible.

was releasing only sufficient water from the reservoirs above Austin to supply irrigation demands. The Guadalupe River had salt water backing upstream almost to the intake of the canal company's pumping station. The Nueces River ceased to flow, as did the Rio Grande.

The ordinary flow of Texas streams is insufficient to meet the heavy summer demands of irrigation and municipal and industrial supply. It is, therefore, evident that planning must be begun at once to conserve flood waters in order to support increasing agri-

cultural and industrial growth. Such conservation is not an insurmountable problem, but it must be worked out on an intelligent basis, primarily by watersheds. It is necessary first to establish adequate gaging and water quality stations on the main streams and tributaries, and to draw up topographic maps of each watershed, showing proposed reservoir sites. The cost of capturing and storing water in these proposed reservoirs can then be calculated. When the origin, quantity, and quality of the water and the cost of storage facilities have been determined for a given watershed, and the potential demands on it estimated, it will be possible to decide whether there is any surplus water available for transbasin diversion.

The governor of Texas, in a letter to the author as his representative on the Arkansas-White-Red Basins Inter-Agency Committee, made this statement: "The formulation of projects for

the comprehensive plan of development of the Arkansas-Red River basins in Texas should be on the basis of economic justification. Texas is not participating in this planning program for the purpose of seeking any form of subsidy. It is prepared, however, to encourage through state organizations or agencies the development of projects found to be economically sound. The existence of almost limitless opportunity in the state makes it unnecessary and unwise to promote unsound projects."

The situation is not one to become alarmed over. Water is available and there are sufficient human ingenuity and individual initiative in Texas today to do what is necessary to provide adequate supplies. When the shortage becomes acute enough or when it becomes economically feasible to impound and conserve flood waters for municipal, industrial, and agricultural uses, those waters will be conserved and put to beneficial use.



Legal Aspects of Water Resources Development in Texas

By Victor W. Bouldin

A paper presented on Oct. 19, 1953, at the Southwest Section Meeting, Houston, Tex., by Victor W. Bouldin, Atty., Vinson, Elkins & Weems, Houston, Tex.

IN Texas, the law of land titles has been highly developed. When a real estate title has been passed upon by capable attorneys, the owner is reasonably certain of the nature and extent of his rights. The same is not true, however, in the field of law relating to water rights, particularly the rights to surface waters. Although an informed lawyer can guide his client in the steps necessary to secure a legal permit to appropriate a portion of the public waters and be fairly sure that the permit is valid as between the client and the state of Texas, that is only the beginning of the task. An appropriation permit is a mere license to divert and use, for stated purposes, a specified quantity of water per year at a specified maximum rate of diversion from a common source in which others have similar rights. It is in the field of relative and correlative rights between the various diverters of water from the same stream or other source of supply that difficulties are encountered. These difficulties stem primarily from three factors: [1] the nature and characteristics of water itself; [2] the evolution and historical background of the state's water laws; and [3] the failure of the state legislature to keep pace with modern requirements in statutory law.

Water, unlike land, is changeable; it may flow intermittently and in undependable volume. As a result, water rights present problems not found in land law. The varied climatic and hydraulic conditions existing throughout the broad expanse of Texas add further complications. These problems are inherent, but they can be resolved.

Other legal difficulties are the result of the influences of six different sovereignties in Texas. The civil or Napoleonic code, the English common law, the American adaptations of the English common law, the statutes and edicts of Mexico, and the laws and court decisions of the Republic of Texas, the State of Texas, and, to some extent, the United States have left their imprint. It is no less true of laws than of people that they are the products of their ancestry. To add to the complexities and inconsistencies in the controlling laws, private rights in public waters, when fixed, become property rights, which are protected by the "due process" and "equal protection" clauses of both the federal and the state constitution.

Ground Water Rights

The Texas supreme court has held that waters percolating beneath the surface of the land belong to the owner

of the land as a part of the corpus of his estate. He may make reasonable use of these privately owned waters without consent of the state and without liability to those of his neighbors who own lands over the same reservoir. The state has no control or right to regulate the use of these private waters except by the exercise of its police powers, to which there has been little resort. In 1949, however, the legislature enacted a statute authorizing the creation of local autonomous ground water conservation districts. These districts have the power to adopt rules and regulations to prevent pollution and waste, but have no authority to limit the rate of production, except to prevent waste as that term is narrowly defined in the act. Through the State Board of Water Engrs., the state health department, and the railroad commission, substantial progress has been made in preventing the pollution and contamination of ground water strata by faulty drilling and casing methods. Except in these matters, the control of ground water use is left generally to the owners of the land.

Surface Water Rights

Surface water law in Texas embodies both the riparian doctrine and the appropriation doctrine, which are, in part, conflicting and incompatible. Prior to 1889 no one could obtain personal and secure rights to use any of the flowing waters of Texas except as incident to his ownership of "riparian lands." Riparian lands are those within a single grant from the sovereign which abut and are contiguous to a flowing stream and which are within the watershed of, and have access to, that stream. Riparian waters, as defined by the state supreme court,

are those of the so-called normal flow and do not include storm or flood waters.

Originally, riparian water could be used by riparian owners only for the so-called natural wants, consisting mostly of domestic water for household purposes, small gardening, and domestic livestock. As the need for broader use of water increased without the requisite legislation being enacted, the courts, through necessity, extended by judicial decree the use of riparian waters to include commercial irrigation, commercial stock raising, milling, mining, water power, and manufacturing. Still unsatisfied, however, was the need for water on nonriparian lands.

In 1889 the legislature belatedly enacted a statute providing that, in the "arid sections" of the state, all waters in the rivers, streams, and lakes belong to the people at large; rights that had already become vested were confirmed, but, thereafter, the right to use public waters could be acquired only by appropriation. This right of appropriation was not limited to riparian lands.

From 1895 on, this new legislative theory, known as the "appropriation doctrine," was extended to cover all sections of the state, whether arid or not. These acts provided that the would-be appropriator simply had to make an affidavit of his intentions to appropriate, setting forth the number of acres to be irrigated or describing the use to be made of the public waters; one copy of the affidavit had to be posted at the point of diversion on the river, and another copy filed in the deed records office of the county in which the diversion was to be made. A map showing the area to be served had to accompany the affidavit re-

corded. The appropriator was not required to own the lands on which the water was to be used. No limits were placed on the extent of land to be served, the maximum rate of diversion, or the maximum volume of water to be appropriated in any year. These were left to the desires of the appropriator.

Water Engineer Board

Under this system, claims of appropriation frequently overlapped and called for more water than the dependable flow of the river would produce. This situation became so confused that, in 1913, the legislature was forced, again belatedly, to establish the State Board of Water Engrs. as an agency to administer the public waters. New appropriations were prohibited, except under permits granted by the board after application, public notice, and hearing. Persons claiming rights of appropriation acquired under former laws were required to file affidavits describing the works constructed, the area served or to be served, and other information, but the act did not specifically attempt to cancel such portions of any declaration of appropriation as had not, according to the affidavit, been put to beneficial use at the time the affidavit was filed. In fact, the legislature enacted new irrigation laws in 1917 which did not merely recognize the continued validity of unused appropriative rights, but actually provided that they should not be canceled except on orders of the State Board of Water Engrs. after public notice and hearing. These statutes, which are still in effect, relate not only to appropriations instituted prior to 1913 (commonly called "certified filings") but also to permits issued by the board since that date.

Thus, the records of the board show the existence of many appropriations—some as much as 50 years old—calling for substantial quantities of water from overburdened streams; in many instances, all or part of such waters has not been put to beneficial use to this day. These unused appropriations, like the unused riparian rights, block the orderly development of Texas' water resources.

The Board of Water Engrs. has made only a few attempts to cancel unused rights, because such efforts usually lead to prolonged and expensive litigation. The legislature should promptly adopt statutes requiring every claimant of a water right in Texas to make proof, within a reasonable time, of the nature of his claimed right, showing the maximum quantity of water heretofore put to beneficial use in any calendar year, the quantity of claimed waters not heretofore put to beneficial use, the maximum rate of diversion, the nature of the use, and other data that will permit the Board of Water Engrs. to inventory and index every water right claimed on every stream in Texas. To the extent that waters have been put to beneficial use, they become vested property rights and should be protected. Unused rights should be canceled after the owners have been given a reasonable period within which to exercise them. Only by such means can the confusion and uncertainties in the water laws be eliminated and the rights of users measured and defined.

The Board of Water Engrs. continues to serve as the state agency administering the water laws of Texas. Generally speaking, it has done a remarkable job with its limited powers and finances. It has no power to ap-

point referees and no authority or means to supervise or police the withdrawal of water by various users from a particular stream. Any conflicts arising between users from the same source cannot be settled on an administrative basis, so that relief can be obtained only by expensive and time-consuming litigation.

The board is not a statewide policy-making agency, and, in truth, Texas has no comprehensive state water policy. The board has no authority or funds with which to construct water conservation facilities. These matters are left to municipal corporations, water districts, or river authorities. There is usually a large number of such agencies in every watershed, and their diversified and uncoordinated activities add to the confusion caused by the absence of a comprehensive statewide water policy.

Not only has Texas failed to adopt an intelligent water policy, but it has made no provision for state financing of dams, reservoirs, and other facilities to store for beneficial use the millions of acre-feet of water lost each year to

the Gulf of Mexico. The quantity of water that falls each year upon the soil of Texas is many times the amount required for its present economy. The task is to provide the means of storing it for use in periods of drought and shortage.

Conclusion

In recent years Texas faced and solved tremendous problems in the field of oil and gas. There is now a sound and constructive legal foundation for the progress of that great industry throughout the state. This result was accomplished only after protracted legal and political controversies, but those who opposed the enactment of the present laws are now among their staunchest supporters. As valuable as the oil and gas industry is to Texas, the water resources of the state are far more important to its welfare and economy. The intelligent conservation of those resources, and their application to uses beneficial to all the people, is the challenge confronting the lawmakers and every other citizen today.

San Jacinto Water Supply for Houston

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F. H. Newnam Jr., N. P. Turner, L. H. Earnest,
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A consolidation of papers presented on Oct. 19, 1953, at the Southwest Section Meeting, Houston, Tex., by F. N. Baldwin, Director, Utilities Dept.; G. L. Fugate, Chief Design Engr., San Jacinto Water Supply, Utilities Dept.; C. R. Harvill, Supt., San Jacinto River Water System, Utilities Dept.; M. A. Dillingham, Prin. Civ. Engr., Ambursen Eng. Corp.; F. H. Newnam Jr., Partner, Lockwood & Andrews, Cons. Engrs.; N. P. Turner, Partner, Freeze, Nichols & Turner, Cons. Engrs.; L. H. Earnest, Prod. Engr., Water Div., Utilities Dept.; and W. K. Van Zandt, Asst. Director, Utilities Dept.; all of Houston, Tex.

IN 1878 Houston, Tex., contracted with a private company to develop and operate a municipal water supply. A small dam was constructed on Buffalo Bayou—then a clear, sparkling stream—from which the water was pumped into the city mains. About the turn of the century an immense underground storage reservoir of fine water was discovered underlying the city. The company thereupon established a well supply, supplemented on occasion by the lower-quality bayou water. In 1906 the city bought the company's holdings for a little less than \$1,000,000. The present value of Houston's water system is approximately \$60,000,000.

As the city expanded, it was found easier to drill wells in the newly developed areas than to transport water from a central location. Consequently Houston now has seven well fields, served by as many pumping stations. Investigations made during the 1930's indicated that no more than 75–100 mgd could be withdrawn from the un-

derground reservoir without excessive pumping heads or danger of salt water intrusion.

By 1943 the city had a population of approximately 400,000, and the water supply problem had attained serious proportions. The 43-mgd maximum production of existing facilities fell far short of the 70 mgd that, according to estimates, should have been available to meet peak demands. Attention was therefore directed to the utilization of nearby surface sources (Fig. 1). The closest of these is the San Jacinto River, which also has the best-quality water. The three other possibilities, in descending order of quality, were the Trinity, Colorado, and Brazos rivers. In 1944 a \$14,000,000 bond issue was voted to finance the development of the San Jacinto supply.

To meet immediate needs, however, part of these funds had to be expended on drilling a new well field and building a new pumping plant that would produce an additional 18 mgd. Furthermore, arterial mains had to be con-

structed to tie the various pumping stations together as a means of overcoming low-pressure difficulties. Also, \$1,000,000—much less than the original cost—was paid to the federal government for the "West Canal" system, which supplies raw San Jacinto water to industries situated on the Houston Ship Channel. These expenditures, together with the rise in construction costs, made it impossible to finance the San Jacinto dam with the money available. The remaining capital was therefore spent, in 1947-48, on wells and pumping plants to increase the capacity to 130 mgd.

Not only did this large withdrawal cause the water table to drop, but the production of individual wells, which have a life of 15-18 years, also began to fall off after about 5 years. The total loss amounted to approximately 6 mgd a year, the equivalent of two new wells. When the problem was aggravated by the annexation of an additional 70 sq miles to the city in 1950, it became imperative to complete the San Jacinto project as soon as possible.

In July 1950 an election was held on the question of issuing \$24,000,000 in revenue bonds. The city council did not conduct an aggressive campaign but simply pointed out to the people that Houston had to have more water and that the proposed bond issue would require a 50 per cent raise in water rates. With the active support of the Houston Chamber of Commerce, the bond issue carried by approximately

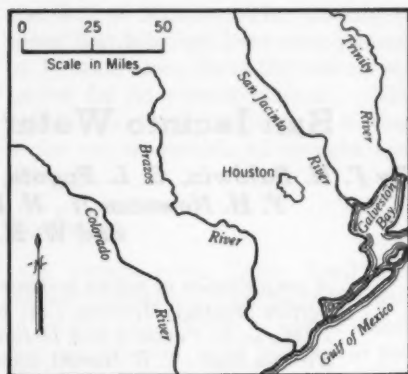


Fig. 1. Houston Vicinity

Of the four rivers shown, the San Jacinto has the best-quality water.

4:1. The bonds were sold in the latter part of 1950.

The several phases of the project were allotted to different consulting firms so that plans could be drawn up and the work carried on simultaneously, in order to complete the entire project by the end of 1953. In addition to the dam, the plans called for building a pumphouse, improving the 14-mile West Canal to increase its capacity from 40 mgd to 200 mgd, constructing a treatment plant, and laying a 7-mile transmission line from there to the city's distribution system. The policy of having a number of engineering firms work in coordination on different parts of the project has made it possible to adhere very closely to the time schedule proposed.

Preliminary Investigations

The tributaries of the San Jacinto River are geologically of the consequent type. They rise in Grimes, Walker, and San Jacinto counties, flow across Montgomery County to Harris

County, and converge into the main stem of the San Jacinto River approximately 8 miles above the site selected for the dam, which is 25 miles northeast of the center of Houston. The

drainage area above the site is 2,800 sq miles. The terrain varies from prairie to gently rolling and hilly country, and is mostly wooded. It will probably remain in this condition for many years. The population density averages 14 per square mile, with a maximum of 21 in the 30-40-mile zone above the dam site. Approximately 44 per cent of the total population is urban.

Hydrologic Studies

A stream flow gage installed in 1928 covered 65 per cent of the total drainage area. Records from 1937 on were also available from a gage near the site of the dam. Pan evaporation stations with good records were located within reasonable distances. It is believed that these stations are reliable sources for predicting evaporation losses from the reservoir.

Three rainfall stations in the general region had data covering 55 years, and a number of other stations had shorter, but fairly satisfactory, records. From stream flow and rainfall data for the same years, it was possible to coordinate and establish a relationship between these two factors. The years 1917-18 were selected as a basis for determining the probable lowest yield. Comprehensive studies of this period were made by the Houston Utilities Dept. staff and by consultants. (A more detailed account of these studies is given by Jens in this issue, page 438.) A drought of this magnitude was found to have a frequency of once in 200 years. Even when this figure is liberally discounted, it can be said with assurance that a drought of similar severity will rarely occur.

It has been unofficially estimated that the basin has a potential safe yield, if fully developed, of between 400 and

500 mgd. The highest flood on record occurred in November 1940, with a discharge of 253,000 cfs at the site of the dam.

Selection of Site

The selection of the dam site was partly affected by the need to prevent a hydraulic conflict with a proposed unit of the Harris County flood control system. Otherwise, the location would probably have been farther downstream. At the site chosen, the available reservoir capacity is 160,000 acre-ft at normal pool level. A flood discharge of 525,000 cfs, twice the largest on record, can be contained within the high banks. A volume of 30,000 acre-ft—estimated to be sufficient for more than 50 years—has been allowed for siltation and bed load deposit. The San Jacinto carries a very small silt load, but, in large floods, the bed load, though of short duration, is fairly heavy. At spillway level, el 44.5, the water surface area is 12,800 acres, providing an average depth of approximately 12.5 ft, with a maximum of 50 ft. The storage area is being completely cleared of timber and other vegetation. The conclusion of the consultants was that this reservoir capacity will provide a safe yield on the order of 140 mgd during a drought approximating the one of 1917-18. For most years, the yield will be on the order of 200 mgd or more.

At the site, the valley of the San Jacinto is approximately 7,000 ft wide. The general elevation of the high banks of the flood plain is 58-60 ft above sea level. The elevation of the flood plain itself is 22 ft, and the low-water mark in the river channel near the eastern high bank is approximately 2 ft.

Foundation exploration was carried on to determine the geologic suitability

ity of the site and to identify the principal strata. Of 29 holes drilled, three were 175 ft deep or more, and most of the others ranged from 80 to 100 ft. A second phase of the work involved the obtaining of detailed information on all the materials encountered. For this purpose, more than 200 holes were drilled, and five test pits, 6 ft in diameter, went down to the uppermost clay stratum.

The recent alluvial deposits along the valley floor have a depth of 22 ft, extending down to el 0. These consist of sands varying from fine to coarse. Beginning at el 0 is the top clay stratum of the foundation area. It is hard and tough, with a thickness of approximately 5 ft. Undisturbed samples of it, when tested in the hydraulic laboratory, withstood velocities of more than 8 fps without erosion. The second stratum is a deposit commonly described as varved clay. The third layer is the upper real Beaumont clay of the foundation area—that is to say, those above it are of more recent deposit, although perhaps of the same origin. It is a greenish-blue clay, varying in thickness from a few inches to several feet and merging gradually into the red Beaumont clay below it. The fifth layer is an unusually hard, sandy Beaumont clay. It is the thickest (45 ft) and most constant of the layers and covers the entire width of the valley.

Samples of these materials were subjected to all of the usual laboratory soil tests. It was concluded that, with proper cutoff walls, the soils provided factors of safety sufficient to insure the stability of the structure to be built on them, with its foundation at el 0.

Pilot Treatment Plant

The results of chemical analyses made over a period of years have estab-

lished that San Jacinto water is of excellent quality. The total dissolved solids average approximately 220 ppm, and the hardness is less than 60 ppm. The sulfate content is very low—less than 3 ppm—a factor of considerable importance because of the many miles of concrete sanitary sewers in Houston. Climatic conditions are very favorable for algae growth, and there is a possibility that disagreeable odors and tastes may develop in a reservoir of such relatively shallow depth as the one under discussion.

A pilot treatment plant was operated for a year to determine the kind and quantity of chemicals needed for the most effective and economical treatment, the rate of filtration obtainable, and the measures necessary to control color, tastes, and odors, if any appeared. The site of the plant was a reservoir of the "saucer" type, storing mostly San Jacinto water pumped into it. The depth averaged approximately 3½ ft when full, and its surface area was 1,285 acres. Only well tried and standard methods of treatment were investigated.

Pilot plant results indicated the appropriateness of the following design factors: a flocculation period of 45 min after flash mixing; a sedimentation period of 3.5 hr, with a flow velocity on the order of 1.2 fpm; and a filtration rate of 3 gpm per square foot of filter area.

It appeared that a satisfactory water could be produced by: prechlorination for color removal and taste and odor control; coagulation with alum; and stabilization with lime and aeration. It is anticipated that the turbidity will normally be maintained at less than 5 ppm, the color at less than 10 ppm, the effluent chlorine residual at 1 ppm, and the pH at 8.2–8.3.

Although the chemical dosages will probably vary between fairly wide limits from season to season, the estimated annual averages are 36 ppm alum, 6 ppm chlorine, and 13 ppm lime. The cost of these chemicals will be approximately \$9-\$10 per million gallons.

Just as important as the proper operation of the purification plant is the

proper control of the lake, if the finished product is to be satisfactory. Although the taste and odor problem never became critical during the operation of the pilot plant, a biological survey of the lake is being conducted continuously, so that undesirable conditions can be remedied before acute difficulties develop.

Design Features of Dam

In engaging the Ambursen Engineering Corp. to design the dam on the San Jacinto River, the city of Houston specified the location of the dam, the capacity of the reservoir, the elevation of the normal reservoir level, and the discharge capacity of the spillway, subject only to such changes as might be found necessary to provide a safe and economical structure. The dam is slightly more than 2 miles long with a maximum height of approximately 65 ft above the bed of the river. The reinforced concrete spillway, 3,160 ft in length, is flanked on both sides by long earth embankments. Completed in December 1953, the dam forms a reservoir (called "Lake Houston") with a storage capacity of 160,000 acre-ft, or 52 bil gal, and, as previously mentioned, will provide a dependable supply of 140 mgd (see Fig. 2).

Structurally, the spillway consists of three parts: [1] a reinforced concrete deck slab, which forms the bulkhead or watertight membrane; [2] triangular-shaped concrete buttresses, which support the sloping deck slab and transmit the weight of the impounded water to the foundations; and [3] a floor designed to spread the weight of the water and the structure uniformly over the entire foundation. The light weight of the structure and the uniform distribution of pressures are particularly advantageous where

the foundation is soft and yielding, as at this site. Other benefits of this design include minimum use of materials and a safety factor several times as high as that of a gravity type dam.

For the Lake Houston Dam, the buttresses were spaced 20 ft apart, center to center. The floor of the spillway rests upon firm clay, with the sandy overburden removed.

The unusual length of the spillway deserves some explanation. The capacity of the spillway must be large enough to discharge safely a flood flow of 525,000 cfs, without raising the reservoir level more than approximately 12 ft. Moreover, it is desired to spread the overflow across the valley as uniformly as possible, to simulate natural conditions and prevent undue scouring of the soft flood plain below the dam, as well as possible failure of the dam due to undermining of the downstream edge of the structure.

Operational studies of the reservoir indicate that frequent overflows will occur during wet years. Special features have been provided to control the discharge so that these flood flows can be passed over the spillway without causing dangerous undercutting. The quieting of the released waters will be accomplished principally by the stilling pool. This feature was formed by continuing the spillway floor horizontally for a short distance and then sloping

the downstream end upward until it reached the natural ground level, thus forming a trough approximately 20 ft deep, into which the water will fall and have its energy absorbed. In order to insure that the overflowing water will be well distributed throughout the stilling pool so that the quieting action will

verified the design computations and showed that the grillage produced efficient stilling action for all ranges of discharge.

As the spillway is located on the flood plain at an elevation higher than the river bed, it was not feasible to release low flows directly into this val-

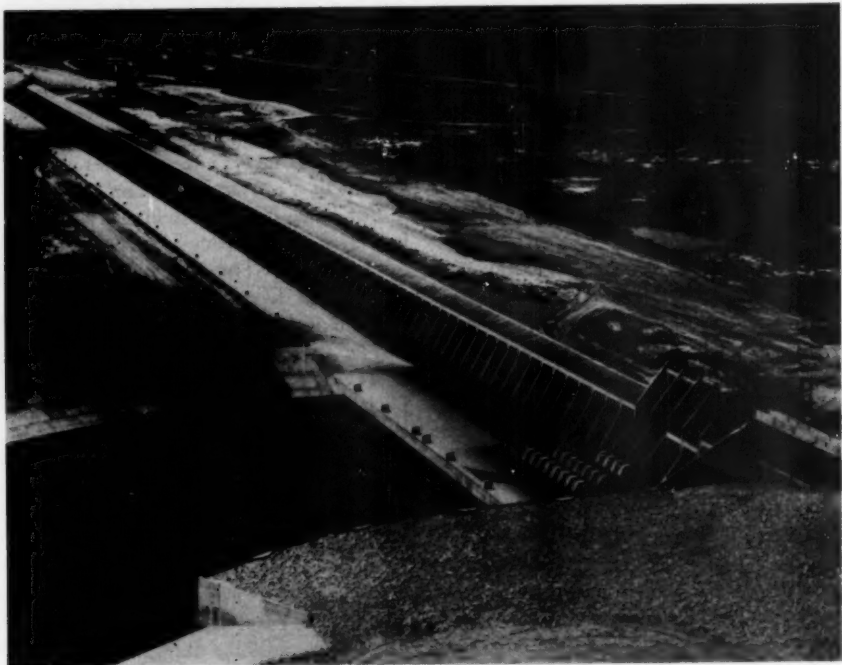


Fig. 2. Lake Houston Dam

The dam forms a reservoir with a storage capacity of 160,000 acre-ft.

be effective under all conditions, a grillage, consisting of reinforced concrete tapered girders, was placed on the crest of the dam. Because this was a new solution to the problem, extensive scale-model tests were conducted at the Institute of Hydraulic Research of the University of Iowa. The tests

ley. To do so would have caused the scouring out of new channels, which eventually would have become as deep as the river. To prevent such scouring action, the stilling pool was designed to convey small flood discharges laterally to its eastern end, where they will empty into a low-flow discharge

channel leading to the natural river bed approximately half a mile below the dam. This lateral diversion of the overflows will occur until the amount discharged floods the entire valley downstream by backwater; thereafter the discharges will flow directly across the stilling pool into the cushion of backwater below the dam.

To achieve maximum watertightness in this structure, the spillway sections, both upstream and downstream, were provided with cutoff walls; sheet-steel piling of the continuous-interlock type was driven down to approximately 25 ft below the foundation floor, to form an enclosed box under each spillway section. A single sheet-steel piling wall was joined to the ends of these boxes and continued under the earth embankment section across the valley so that positive control of underseepage would be effected.

The compacted earth embankment comprising the nonoverflow section of the dam is designed to utilize the materials found at the site, a large quantity of which was obtained from the required excavation for the spillway and the low-flow discharge channel. The porous sandy foundation under the embankment was excavated to economical depths, and a sheet-steel piling cut-

off was driven through the sandy material into the underlying clay. The core trench was backfilled with clayey material, encasing the piling and joining the clay core wall, which extends to the top of the dam, to provide a watertight embankment. The outer shell of the embankment was made from porous sandy material. The side slopes were protected against wave action and erosion by placing an 18-in. layer of riprap over a 9-in. blanket of gravel.

Other features of the dam include a 36×36 -in. sluice gate to maintain the circulation of fresh water through the length of the stilling pool and to permit low-flow discharges to satisfy the riparian rights below the dam. Two Tainter gates, $20\frac{1}{2}$ ft high and 18 ft wide, have been provided to enable the level of the reservoir surface to be varied frequently during the mosquito breeding season, thus destroying the malaria-carrying larvae that are usually concentrated in the shallow water at the extreme edges of the pond. Two hinged steel flashboards, 18 ft long and 6 ft high, will furnish a means of skimming trash and drift material from the surface of the reservoir. The gates and flashboards will be operated by individual stationary hoists.

Dam Pumping Plant and Canal

This portion of the discussion will describe the essential features of the structures required for withdrawing the water from Lake Houston and transporting it to the Houston Purification Plant, located approximately 14 miles to the south. These structures, estimated to cost \$4,400,000, include an intake tower, an intake conduit, a pumping station at the lake, and

a lined canal from the lake pumping station to the forebay pumping station near the purification plant (Fig. 3). Fortunately, the ground surface slopes gently from north to south, permitting gravity flow through the canal.

Various factors had to be given consideration in determining the best location for these installations. The lake pumping station had to be on high

ground to protect it from floods. The intake tower had to be as far into the lake as possible, in order to insure a good selection of fresh water; as near to the dam as possible, to minimize the cost of the connecting bridge; and as near to the pumping plant as possible, to reduce the cost of the expensive intake conduit. The selected sites provide the best possible balance between these conflicting requirements.

Particular attention is invited to the fact that, throughout the intake tower, intake conduit, and lake pumping plant, a dual system is employed. Half of each unit can be completely isolated for repairs or other purposes while the other half remains in use.

Intake Tower

The reinforced concrete intake tower is approximately 34×29 ft in cross section and 65 ft high, exclusive of the foundations. Numerous soil borings and tests were made, not only to aid in the design of the footings, but also to insure that construction would not produce any detrimental effect on the stability of the dam or induce seepage beneath it. Underream footings were selected because of their economy and because they would provide stability against the weight of the structure itself, as well as resistance to uplift during flood stage in the lake.

It was believed essential to be able to select water from any level in the lake. Consideration was first given to employing three staggered gates to cover the range of water depth in the reservoir. It was determined, however, that, because of the relatively shallow depth of water, better selectivity could be obtained with two staggered sluice gates, with openings of 8×10 and 8×8 ft, respectively.

Both gates open by sliding either up or down. The bottom draft was set at el 27.5, where 90 mgd can be withdrawn from the lake. The design capacity of 200 mgd can be obtained when the water is at any elevation above 31 ft, a level which reservoir

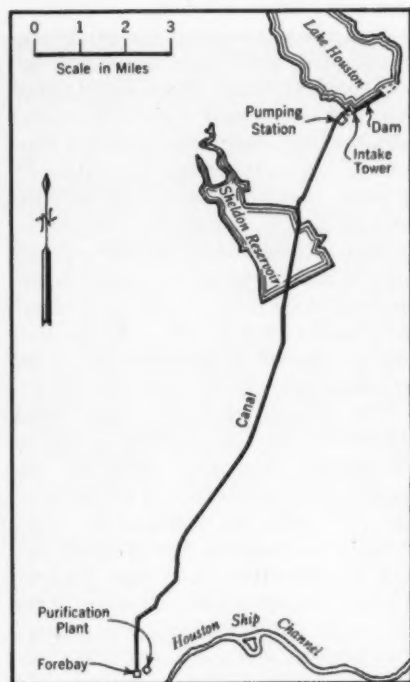


Fig. 3. Location Map

The canal is approximately 14 miles long.

operation studies show will be exceeded more than 99.5 per cent of the time.

The two entrance channels of the intake structure contain a bar screen trash rack fabricated in 4-ft sections which can be raised and removed by a chain hoist installed in the superstructure. This hoist can also be used

to drop stop logs into recesses provided for them, in the event that the entire unit or one side of it is to be closed off and dewatered for repairs. Floating debris will be removed manually from these trash racks and deposited in a small cart that travels on rails and can be pushed by hand across the bridge to the dam. At a point near the dam, the trash can be dumped into trucks and hauled away. Mechanically operated screens in back of the trash racks and in the inner chambers will remove small particles of debris.

Inside the tower, a 12-in pipe well with connections to the reservoir permits the installation of a float attached to an automatic recording gage, which will show the elevation of the water in the lake at all times.

A bridge supported on two hinged arches joins the intake tower with the west abutment of the dam. The bridge has a clear span of 140 ft and an inside width of 14 ft. It is designed to handle only foot traffic and the previously mentioned trash cart, but it can be used to haul relatively light equipment like motors to or from the tower. The construction cost of the intake tower was \$165,000.

The two 72-in. conduits between the intake chambers and the lake pumping plant are constructed of monolithically poured reinforced concrete. The construction cost of the conduits, which are approximately 1,160 ft long, was \$265,000.

Pumping Plant

The pumping plant is constructed of reinforced concrete with masonry exterior and tile interior. The building, approximately 88 × 30 ft, has two 17 × 30-ft one-story wings. An intake conduit empties into each of the

two separate compartments of the wet well, which has a bottom elevation of 15 ft. The two wet well compartments are connected by a gated opening that can be closed in order to dewater and make repairs in either of them. As a result of soil tests, it was concluded that the pumping station should rest on underreamed footings in order to transfer the load to a stable soil layer and provide resistance against uplift. Most of these footings did not have to go below el - 2, but a few were carried to greater depths because of unsatisfactory soils.

The first floor is at el 30, the discharge floor at el 50, and the operating floor at el 63. The main pump-room, which has a vertical clearance of 17 ft, is equipped with a 10-ton, 25-ft span overhead crane that travels on two rails extending the full length of the room. The pumping station also contains an office, workshop, and laboratory.

Although there is space for six pumps and motors, the initial installation consists of only four—two over each compartment of the wet well—having a capacity of approximately 121 mgd at normal lake level, with the largest pump out of operation. All the pumps are of the vertical centrifugal type with mixed-flow impellers. Two of the pumps have synchronous motors with ratings of 300 and 500 hp. Two variable-speed induction motors, 100 and 200 hp, were selected for the other pumps to provide against the loss in capacity that ordinarily would have resulted from increased pumping heads due to receding lake levels. It is believed that this arrangement of pumps and motors offers the optimum balance between flexibility and efficiency. By adding two more pumps,

a firm capacity of more than 200 mgd—the design capacity of the lined canal—could be obtained with the largest pump out of operation.

A power station constructed adjacent to the pumping plant serves this installation, as well as the intake structure. If the electricity should fail, a 300-kw diesel-driven emergency power unit in the pumproom is capable of operating two pumps with a combined capacity of 50 mgd. Space is available for a second 300-kw unit to be installed when the pump capacity is increased.

The pumps deliver the water through individual venturi tubes into a forebay which is 65 ft wide at the point of discharge. A 60-ft section joins the forebay with the lined canal.

A small building next to the pumping plant houses pressure filter treatment facilities, with a capacity of 120,000 gpd, which supply potable water for the installation. Storage and some fire protection are provided by a 25,000-gal elevated tank.

The pumping plant area is landscaped and has curved roads and parking areas. For the benefit of sightseers, an observation platform has been built over one of the plant wings to furnish a view of the lake and dam.

The total construction cost of the pumping station and appurtenances was \$754,000.

Lined Canal

Houston now owns a 40–50-mgd earth canal, including right of way, that extends from an old pumping plant at the San Jacinto River to the forebay near the new water purification plant, a distance of approximately 14 miles. This canal passes very close to the new lake pumping plant. The

condition of the canal differs from section to section.

The present construction contract calls for dewatering and drying the existing canal, shaping it to the required true grade, and lining it with 4 in. of reinforced concrete. The bottom width varies from 4 to 8 ft. The sides have a 30-deg slope; a steeper inclination was precluded by poor soil conditions, which also necessitated reinforcement throughout the length of the canal. The average vertical depth is approximately 5½ ft. The concrete lining will provide 1 ft of freeboard above the hydraulic gradient at the ultimate capacity of 200 mgd. Above the concrete is 1½ ft of freeboard on the earth levees. A patrol road runs the full length of the project, which is also fenced.

The plans call for eliminating or improving the siphons and other crossings. Of the 19 existing siphons, 5 will be discarded, 9 will be replaced with culverts, and 5 will be enlarged to the new design capacity. Most of the eliminated siphons are located at drainage crossings; the new plan calls for the drainage to be carried under the canal in a much smaller siphon. At road crossings, reinforced concrete overpasses will be supported on piers. The minor losses of head due to the central piers will be taken into account in the design.

Except for a section of steel pipe under one of the major stream crossings, all of the new siphons will be constructed of precast, reinforced concrete pressure pipe. Four spillways are provided throughout the 14-mile distance, each with 70-mgd capacity at a head of ½ ft.

One feature that has proved troublesome is the existing Sheldon Storage

Reservoir, through which a section of the canal passes. Consideration was given to retaining this reservoir for additional storage and flow equalization. This plan was rejected, however, because the reservoir is shallow and has an abundance of plant growth, which would materially increase the taste and odor problem. It was decided, therefore, that the canal should be carried through the reservoir but isolated from the waters contained therein. Houston subsequently sold the reservoir, exclusive of the canal right of way, to the Texas Game and Fish Commission.

The plans provide for the removal of the existing top layer of muck along the route of the new canal within the Sheldon Reservoir. Two levees will be constructed out of material brought in from selected borrow sources, as none of the soil in the reservoir is suitable for this purpose. The levee on the west side is to be provided with concrete surfacing, to minimize damage from wave action and other ero-

sion factors. The contractor intends to throw up a temporary coffer dam levee to permit the dewatering of the canal right of way and the east side of the reservoir, which will become a game preserve.

At the lower or purification plant end, the canal will discharge through a siphon into an existing 15-mil gal forebay made entirely of earth. After considerable study, it was decided, for the sake of economy, merely to build up the existing levees and line the inside slopes to provide protection against wave action.

During the canal construction, 40 mgd of water will continue to be supplied to industrial users through a temporary ditch located within the limits of the canal right of way but completely outside the canal itself. In one 3-mile section, where the right of way is too narrow for a ditch, it will be necessary to lay a pipeline and pump the water.

It is expected to complete the canal late in 1954, at an estimated cost of \$3,200,000.

Houston Purification Plant

In the Houston Purification Plant, an attempt has been made to integrate some of the latest developments in industrial design with time-proved principles of municipal water treatment. The plant embodies no radical departures from accepted treatment methods, but, being uninhibited by older structures, its design results in an engineering and architectural integration of function, efficiency, economy, and pleasing appearance.

The plant (Fig. 4) is designed to supply the maximum 24-hr requirements of a system whose average de-

mand is 50 mgd. Initially the plant is equipped for an average demand of 33 mgd. It is capable of operation at 200 per cent of the average demand. The plant site has sufficient space for expansion to 200 mgd. Operating in conjunction with the plant is a separate pumping station delivering 75 mgd of untreated water to industries along the Houston Ship Channel.

Inasmuch as San Jacinto River water is low in hardness, alkalinity, and turbidity, the treatment process is not complex. A high quality of water is obtained through prechlorination, co-

agulation with alum, settling, filtration, and stabilization with lime. Activated carbon and chlorine can be introduced occasionally in dealing with objectionable tastes and odors.

Raw water flows from the forebay to measuring flumes and rapid-mix

Each treatment basin has seven three-stage, axial-flow flocculation units. Radial sludge-collecting mechanisms and corner rakes are installed in the first half of each settling basin. Construction of the filters parallel to the discharge ends of the settling ba-



Fig. 4. Houston Purification Plant

The canal terminus, raw-water pumps, and chemical-handling facilities are at left. The distribution pumping station is in the foreground, at right.

units, where the coagulant is introduced. Flocculation and settling then take place in three basins, from which the water flows to twelve filters. With treatment completed, the water is adjusted to proper pH and pumped to storage and into the distribution mains.

sins and use of the intervening space as a two-story channel for treated water and for wash water disposal have eliminated more than half the piping ordinarily required.

All large pipe in the plant is either fabricated steel or concrete. Weight,

price, and greater dimensional flexibility were the determining factors in the selection of steel over cast-iron pipe. Rubber-lined butterfly valves are installed on all large low-pressure piping. A saving of \$124,000, in addition to the saving of space involved, was realized through the use of butterfly valves in lieu of gate valves.

The employment of outdoor pumping stations for lifting the raw water, for passing the filtered water to the clear wells, and for supplying raw water to industries results in a considerable saving in cost at these three points in the plant. Owing to maintenance requirements and motor sizes, the distribution pumps are housed in a conventional structure.

The chief operator exercises primary supervision of the plant from the filter operating gallery, where he controls the raw- and filtered-water pumps and the filters proper, constantly maintaining sufficient clear well storage. The flow of settled water to the filters is automatically proportioned by rate controllers. Automatic chemical feed

is controlled by the flow of raw water through Parshall flumes. Chemical dosage is varied by an operator in the chemical building, on instructions from the laboratory. Continuous laboratory control of the entire treatment and disinfection process is maintained in the laboratory, where seven continuous-flow sampling lines provide water from different steps in the process.

Operating information from each step is indicated and recorded on a central chart panel in the administration building. Large graphic panels, located over the central chart and filter control boards, show a complete flow diagram, color coded to each instrument, to simplify training of operators and give visitors a quick and comprehensive understanding of the plant functions.

The plant was designed and its construction supervised by Freese, Nichols, and Turner, Cons. Engrs., Houston, Tex. The total cost was \$4,900,000, of which \$385,000 was for a separate raw-water pumping plant for industrial supply.

Hydrologic Considerations in the San Jacinto Project

By Stifel W. Jens

A paper presented on Sep. 29, 1953, at the Missouri Section Meeting, Excelsior Springs, Mo., by Stifel W. Jens, Cons. Engr., St. Louis, Mo.

IN planning the development of the San Jacinto River as a source of supply for Houston, Tex., it was necessary to determine the probable dependable stream flow, as well as the maximum probable spillway flood from 2,840 sq miles of the San Jacinto watershed above the proposed dam site. At Huffman, Tex., a few miles above the dam, the main stream (2,791 sq miles of tributary area) has been gaged since October 1936. A somewhat longer stream flow record, starting in October 1928, was available near Humble, Tex., for 1,911 sq miles of the West Fork drainage area. The studies described in this paper were made in 1944 and utilized the stream flow records through September 1943 (1).

A relatively long record of rainfall was available, with 55 years at three stations in this general region and somewhat shorter, but fairly satisfactory, records at a number of other stations (Fig. 1). The short stream flow record made it necessary to study the location, extent, and intensity of precipitation, as well as the meteorological conditions attending great recorded storms, in the general vicinity of the project; the probability of occurrence of these great storms above the dam site; and the probable peak flows resulting from them.

The Huffman stream flow record, along with the rainfall data, indicated six hydrograph rises worthy of detailed study—those of November and December 1940, April and October 1941, April 1942, and July 1943. Mass rainfall curves were developed for every rainfall station in and around the basin for each of the six storms, primarily to secure an indication of time of excess rainfall (actual rainfall less infiltration). This information was then used in developing "unit hydrographs."*

For the May 1929 and November 1940 storms, the US Geological Survey, using high-water marks, had estimated the peak flows at Huffman as 237,000 and 253,000 cfs, respectively—the highest experienced. For the November 1940 storm, 12-hr rainfall amounts, obtained from isohyetal maps (showing lines of equal rainfall), were apportioned into hourly amounts, based on the hourly distribution of the rainfall as given by the recording gages nearest the basin. The total equivalent uniform rainfall depth over the 2,800 sq miles was 11.7 in. This detailed study of the storm causing the largest flood flow on record in the basin was

* A description of this very important hydrological technique may be found in most standard works on the subject, such as that by Linsley and others (2).

undertaken to develop the best possible techniques for translating the rainfall of a great storm into stream flow for this particular watershed.

Storm Study

Figure 2 gives area-depth curves for the seven greatest storms recorded in the general region, as obtained from US Army Corps of Engineers reports (3, 4). It can be seen that the three greatest, for 2,800 sq miles, were those of Aug. 6-9, 1940, in southwestern

fall. Only the August 1940 storm, which proved to be the one that would have produced the greatest peak flow at the dam site, will be discussed in detail here.

This storm, a tropical hurricane originating in the Gulf of Mexico, moved inland over the extreme western Louisiana coast on Aug. 7, 1940. Traveling northwestward, the storm passed approximately 8 miles south of Port Arthur, Tex., and then curved gradually to the north and northeastward. After striking Port Arthur, the disturbance diminished rapidly in intensity, except for torrential rains in western Louisiana and the extreme eastern part of Texas. The approximate center of precipitation for the storm was 50 miles south and 190 miles east of the center of the San Jacinto Basin above the dam site. Topographical differences did not have to be considered in transposing this storm to the San Jacinto Basin. Other tropical hurricanes, notably the August 1915 storm, had passed inland farther to the west.

From the data supplied by the Weather Bureau, mass curves were drawn for each of the rainfall stations in the area of heaviest precipitation, and, from these, isohyets were drawn for each 12 hr of the Louisiana storm. On the isohyetal maps, the boundaries of the San Jacinto watershed were superimposed, with no rotation of the directional axes. Rainfall quantities within the superimposed boundaries were then accumulated to obtain 12-hr totals. Excess-rainfall values were obtained by subtracting the estimated infiltration losses. The latter were computed on the basis of wet antecedent conditions, using infiltration rates established for sandy soils at the Tyler, Tex., Experiment Station of the US



Fig. 1. San Jacinto Impoundment Area

Three of the gaging stations shown provided a 55-year rainfall record.

Louisiana; Jun. 27-Jul. 1, 1899, centered at Hearne, Tex.; and Sep. 6-10, 1921, centered at Taylor, Tex. The last two had been carefully studied by the Corps of Engineers, but it was found necessary to make a complete analysis of the 1940 storm, using US Weather Bureau information (5). In the interest of a conservative appraisal of the possibilities, it was assumed that all three could have occurred over the San Jacinto Basin, with no reduction in either the rate or the amount of rain-

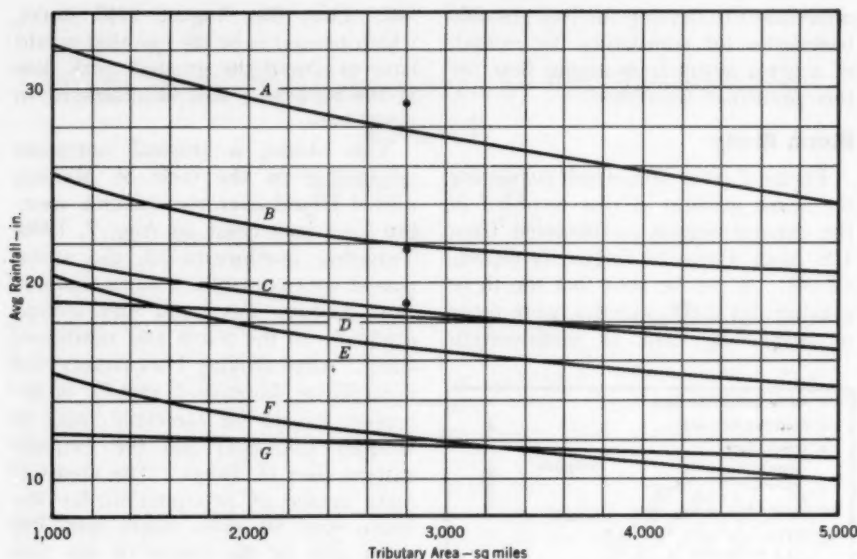


Fig. 2. Area-Depth Curves for Great Storms

The curves relate to the following storms: A—southwestern Louisiana, Aug. 6-9, 1940 (3.5 days' duration); B—Hearne, Tex., Jun. 27-Jul. 1, 1899 (3 days' duration); C—Taylor, Tex., Sep. 6-10, 1921 (2.5 days' duration); D—Aug. 16-20, 1915 (4 days' duration); E—Sep. 15-17, 1936 (3.5 days' duration); F—Dec. 6-8, 1935 (1.5 days' duration); G—split rainfall, May 24-31, 1929 (5 days' duration). Values obtained by transposing Storms A-C to San Jacinto watershed are indicated by ●.

Soil Conservation Service. For the entire 2,840-sq mile area, the rainfall, losses, and excess (runoff) were 29.3, 6.6, and 22.7 in., respectively.

The excess precipitation for each 12-hr period was applied to the unit hydrograph previously developed, in order to construct the probable hydrograph of a storm similar to the Louisiana hurricane if it had been centered over the San Jacinto watershed. Figure 3 shows this synthetic hydrograph, as well as others, for the Hearne and Taylor storms, obtained in the same way. Also shown is an actual hydrograph, labeled "San Jacinto," for the storm of November 1940.

The estimated hydrograph for the Louisiana storm indicates a peak of 517,000 cfs, which was believed to be close to the probable maximum. The design figure actually used was 525,000 cfs.*

Dependable Flow

The probable dependable stream flow at the dam site is another very important factor in designing a water supply impoundment. As rainfall re-

* A safety factor of 25 per cent above the estimated peak of 517,000 cfs—which would have resulted in a design figure of 650,000 cfs—was originally recommended, but economic and other considerations subsequently led the city to adopt the 525,000-cfs figure.

ords usually cover a much longer period than the available stream flow data, the initial step is an examination of the precipitation data to determine and compare the periods of deficient rainfall, and, if possible, to select a dry period that might reasonably result in the critical minimum runoff for the watershed.

After this study had been made for the San Jacinto Basin, there was next

and runoff that could then be applied to the rainfall of the selected dry period to determine the probable runoff during that time. Using this computed runoff, a mass curve of inflow into the proposed reservoir was prepared, and studies of dependable yield of reservoirs of various capacities were based upon it. A brief description of the procedures employed may be of interest.

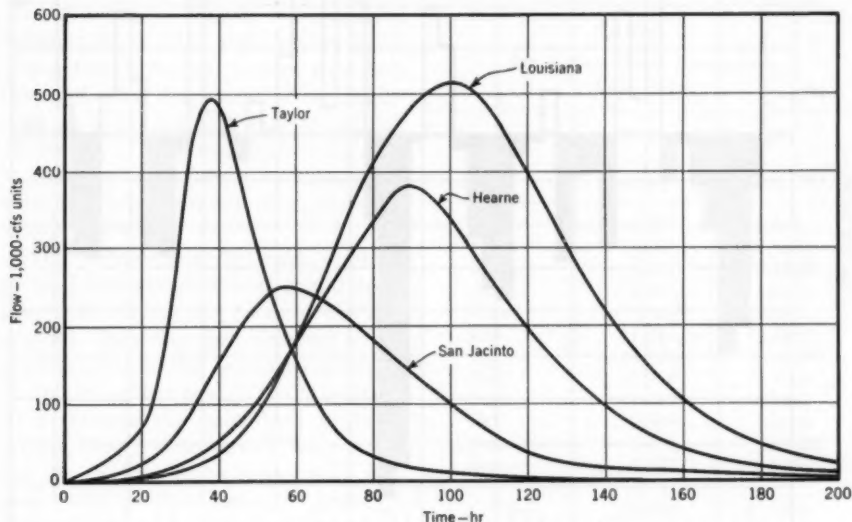


Fig. 3. Flood Hydrographs at Proposed Dam Site

The curve labeled "San Jacinto" is an actual hydrograph of the storm of Nov. 22-25, 1940. The other three curves are synthetic hydrographs of transposed storms.

developed a correlation between the very short stream flow record at Huffman—which, fortunately, is almost at the chosen dam site—and the somewhat longer record at Humble, so that the latter could be transferred to Huffman. From the recorded stream flow at Humble and the rainfall data for the same years, it was possible to work out a relationship between rainfall

The monthly rainfall totals for all of the stations in and adjacent to the San Jacinto Basin were carefully weighted by the Thiessen method, to determine the equivalent uniform rainfall for both the entire basin above Huffman and the West Fork above Humble. From these weighted monthly rainfall data for April 1899 to October 1943, there were prepared mass diagrams and bar

graphs, like Fig. 4, showing the fluctuations about the average. The most critical period of rainfall deficiency was shown by these plottings to be 1916-18.

Further study revealed that the run-off for most years is divided into two

March, and a 7-month "growing" season, April through October, although the distinction between growing and dormant seasons in the San Jacinto watershed is not so sharp as in more northerly regions. The fact that rain-

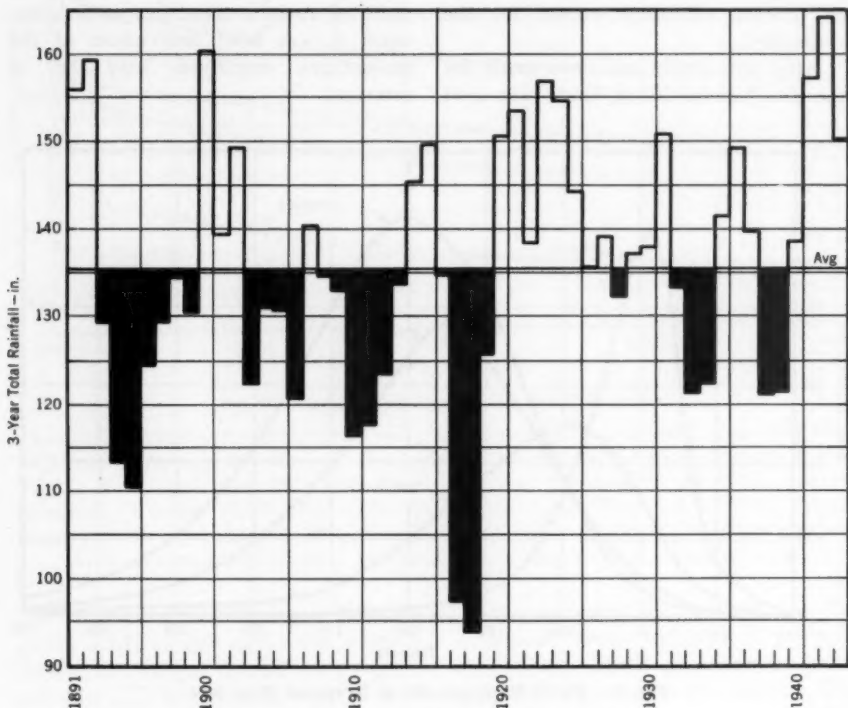


Fig. 4. Three-Year Total Rainfall

Each bar indicates the total rainfall for the year given and the preceding 2 years; for example, the total rainfall for 1889-91 was approximately 156 in. The average 3-year total was 135.28 in. The filled-in segments represent the amounts by which the totals fell short of the average.

periods of distinctly different character, with the tendency for a seasonal change to occur, on the average, about Apr. 1 and Nov. 1. Accordingly, the year was divided into a 5-month "dormant" season, November through

fall is fairly uniformly distributed throughout the year indicates that the runoff differential between the two seasons is primarily connected with a change in water losses from evapotranspiration and, therefore, to a re-

lated change in mean temperature. The dormant season has a mean temperature of 53.8°F, compared with 76.6°F for the growing season, while the average runoff is, respectively, 0.73 and 0.40 in. per month.

A study of the seven drought periods from 1889 to 1943 showed that, although the lowest rainfall for a single season was recorded in the period November 1903–March 1904, the minimums for two, three, four, five, and six consecutive seasons all occurred between April 1915 and October 1919. (In a few instances, stream flow records indicated that runoff at the beginning of a season was due to rainfall at the end of the preceding season, and adjustments were made to include the related rainfall and runoff in the same seasonal totals.)

The relationship between seasonal rainfall and actual runoff found from the yield studies for each of the two seasons (growing and dormant) was then applied to the seasonal values in the drought period 1915–19 in order to determine the minimum probable stream flow. Calculations were made for two sets of three consecutive seasons within this period: growing-dormant-growing and dormant-growing-dormant.

Extensive probability studies were made to determine the frequency of occurrence of a drought period similar to that under investigation. These studies were also useful as a guide in drawing maximum-loss curves. Although the 1915–19 drought occurred within a recorded period of 50 years, its probability of recurrence is actually on the order of once in 200 years or more. Even if the validity of using probability studies of this kind in their extreme range is questioned, it still

appears safe to assume that such a drought period will not occur more than once a century.

The finally recommended mass curve of reservoir inflow incorporated the minimum three-season runoff obtained by subtracting the maximum water losses from the actual three-season rainfall for the critical period. For the 18 months from Apr. 1, 1917, to Oct. 31, 1918, the total computed runoff was 1.65 in.

TABLE 1
*San Jacinto Basin Evaporation
Data, 1916*

Month	Evaporation Loss	
	per cent*	in.
Jan.	3.327	1.8331
Feb.	4.501	2.4800
Mar.	6.262	3.4505
Apr.	8.023	4.4209
May	9.785	5.3914
Jun.	11.546	6.3618
Jul.	12.524	6.9010
Aug.	12.916	7.1166
Sep.	11.742	6.4697
Oct.	9.589	5.2836
Nov.	6.458	3.5583
Dec.	3.327	1.8331
<i>Total</i>	100.000	55.1000

* Based on Meyer study (6).

Evaporation and Seepage Losses

To determine the storage volume required for assumed water demands, it is also necessary to know the evaporation losses from the water surface of the impoundment. A Minnesota Resources Commission study (6) of evaporation from lakes and reservoirs, based on 50 years of weather records, gives excellent annual and monthly evaporation maps for the whole United States. Based on data from this re-

port, well substantiated by other studies, evaporation values were calculated for the critical drought period, 1915-19. Table 1 shows the monthly values for 1916. The average monthly values, in inches, were multiplied by the reservoir surface area and the result converted to acre-feet. All of the yield studies started with the assumption of a minimum pool of 50,000 acre-ft in November 1915.

In addition to computing evaporation losses, corrections for rainfall on the reservoir and for seepage loss through the bottom of the impoundment were made in arriving at the desired storage volume for each of several assumed rates of supply. The seepage value was arbitrarily set at 200 acre-ft per month, taking into consideration the nature of the underlying formations. As the rate of movement through sands of the type involved has been found by the US Geological Survey to be extremely small, the seepage loss figure adopted is believed conservative.

It was determined that, with a drought period like the one discussed, an average annual demand of 140 mgd required 99,600 acre-ft of effective

storage; 150 mgd, 108,900 acre-ft; and 160 mgd, 116,100 acre-ft. To each of these figures must be added a minimum of 50,000 acre-ft of dead storage, desirable primarily to maintain the best possible quality of water during dry periods.

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Mechanism of Corrosion Inhibition by Sodium Metaphosphate Glass

By James C. Lamb III and Rolf Eliassen

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SODIUM metaphosphate glasses have been used for a number of years to inhibit corrosion in municipal and industrial water systems. Shortly after the introduction of metaphosphates as corrosion inhibitors, Hatch and Rice (1) advanced the theory that the inhibitory action was due to the formation of a protective film of metaphosphate on the metal surface. At that time the exact mechanism by which this film was deposited was not described in detail.

In 1950 Mansa and Szybalski (2) concluded that the inhibitory action of metaphosphate, in differential aeration cells, was due to the formation of a protective film on the cathodes, resulting in reduced cathodic potentials. These investigators attributed the film formation to adsorption of large molecules of metaphosphate, or its complexes, on the exposed surface of the metal.

In 1946 Evans (5) classified metaphosphate as an anodic inhibitor, on the basis of unpublished results. In 1951 the same author (6) stated that it was probably a cathodic inhibitor and mentioned the possibility of colloidal action. No data were presented at that time.

phosphate served to stabilize this protective film.

Also in 1952, Hatch (4) found that metaphosphate acted preferentially at the cathodes of corrosion cells. He concluded that it should be classed as a cathodic inhibitor, and that the inhibitory action was due to the electrodeposition of a film of calcium metaphosphate complexes on the cathodes.

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In order to obtain a proper evaluation of the efficiency of metaphosphate glasses as corrosion inhibitors, it is necessary to determine the inhibitory mechanism. Such knowledge should lead to a more accurate concept of the variables affecting the action of the chemicals, and should result in increased efficiency and economy in their use for the control of corrosion in municipal and industrial water systems. The research reported in this paper was undertaken for the purpose of determining the mechanism by which a

sodium metaphosphate glass inhibited the corrosion of iron in water.

Continuous-Flow Equipment

The limitations of batch testing procedures have been pointed out by Hatch (7). Of particular importance is the fact that the total amount of inhibitor available to the metal is limited to that present in the beaker, whereas, under continuous-flow condi-

in Fig. 1. A 5-gal glass carboy was used as a reservoir for the corrosive water. This reservoir was immersed in a constant-temperature bath, which was maintained at $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The concentration of dissolved oxygen was maintained at a constant value by continuous aeration. The corrosive water was circulated in the test system at a constant rate of flow by means of a stainless-steel centrifugal pump. All

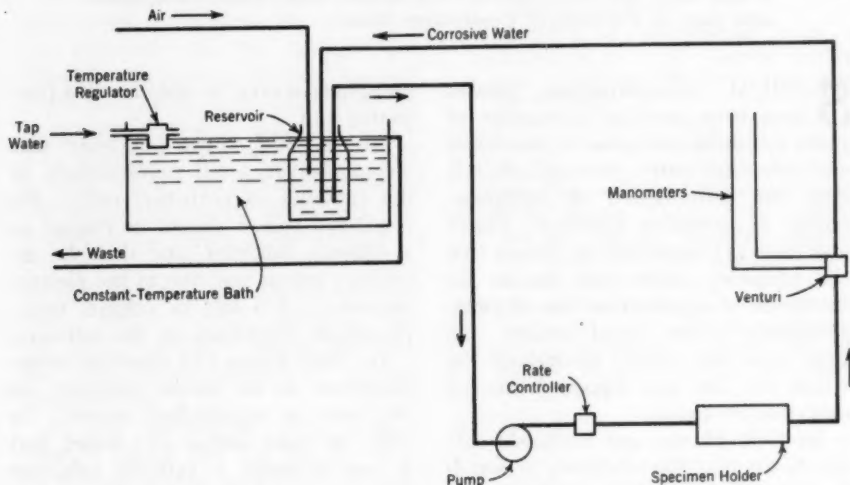


Fig. 1. Flow Diagram of Test Equipment

The reservoir is a 5-gal glass carboy. The temperature was $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$. Water was circulated at a constant rate.

tions, there is a constant supply of inhibitor to the metal surface. The effect of velocity on the rate of corrosion of iron in water has been known for many years (5, 8, 9). It has been found (7) that the effect is even more pronounced in metaphosphate-treated waters.

The experimental equipment used in the initial phase of these studies was of the continuous-flow type, as shown

pipes in the system were made of pyrex tubing or rubber hose. Hence, the water did not touch any metal in the test system, with the exception of the stainless-steel pump and the corroding specimens.

Figure 2 shows the specimen holder which permitted the removal of specimens at various times during a run. Each specimen holder was designed for eight galvanic cells. The use of baffles

in the holder resulted in the formation of eight identical compartments. This arrangement provided similar flow conditions in the vicinity of the two electrodes of each galvanic cell.

The specimens were machined to a diameter of 0.900 in. and a thickness of 0.25 in., in order to permit them to fit into the special cups used with standard radioactive counting equipment. The face to be exposed to the water was prepared in accordance with

trodes on opposite sides of the specimen holder were normally short-circuited by means of small sections of wire, to form galvanic pairs of anodes and cathodes.

When it was desired to remove specimens in order to determine the deposit of metaphosphate, the flow through the system was stopped. The rubber hoses were pinched shut to prevent loss of water from the system, and two specimens, comprising a galvanic

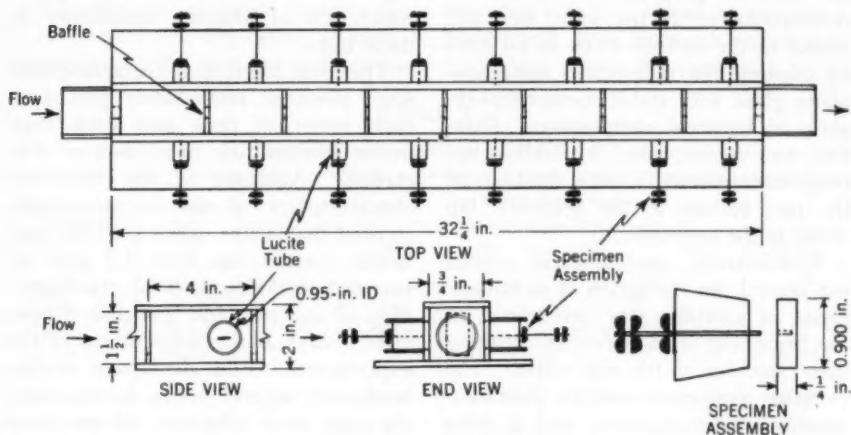


Fig. 2. Specimen Holder

This arrangement provided similar flow conditions in the vicinity of the two electrodes of each of the eight galvanic cells in the holder.

standard laboratory techniques for handling corrosion specimens. All of the metal, except for this face, was waterproofed with a mixture of beeswax and paraffin. Bolts were passed through rubber washers and screwed into the tapped holes on the back faces of the specimens. The specimens were mounted in the holder by inserting these assemblies into lucite tubes, placing the exposed faces flush with the inside of the lucite channel. The elec-

cell, were removed from the specimen holder and replaced with rubber stoppers. It was possible to accomplish this change in 2-3 min, without wasting more than a few drops of water.

Radiochemical Analyses

The quantities of metaphosphate deposited on the anodes and cathodes were usually very small. The use of radioactive tracer techniques made it possible to determine the amounts of

these deposits without removing the protective films from the metal.

The metaphosphate used in these tests was a glass, prepared in the laboratory from phosphoric acid and sodium carbonate, with a P_2O_5 content of 67.5 per cent. This approximates the makeup of a commercial product used for the control of corrosion in potable-water systems. A trace amount of radioactive phosphorus (H_3PO_4 containing P^{32}) was added to the mixture at the time of preparation. Levels of radioactivity in the test water were adjusted to the desired value in all runs by diluting the radioactive metaphosphate glass with stable metaphosphate glass of identical composition. Dilution was accomplished by adding appropriate amounts of stock solutions of the two glasses to the synthetic tap water in the reservoir.

Radioactivity, measured in counts per second per milligram of metaphosphate in solution, was determined at the beginning of each run by counting three samples of the test water. The counting equipment used for the radiochemical determinations was a mica window type of Geiger-Muller counter, with automatic sample changer. This equipment has been described in a previous paper (10). The same counter was used throughout all tests.

After removal from the test assembly, the specimens were placed in nickel-plated counting cups and counted three times. Corrections were made for background, geometry, and decay of the radioactive phosphorus. The amount of deposit on each specimen was determined by relating the corrected counts per second of the specimen to the counts per second per milligram of metaphosphate in the corrosive water. All deposits were ex-

pressed as milligrams of metaphosphate per square decimeter ($sq\ dm$) of apparent metal surface.

These techniques did not permit differentiation between metaphosphate and orthophosphate. Because both types of chemicals are used as corrosion inhibitors, and because metaphosphate reverts to orthophosphate, there may be some question whether the protective film consisted of the latter. There are several reasons for believing that it was the metaphosphate which was of primary significance in these tests.

The stock solutions of metaphosphate were prepared immediately preceding each series of runs and were kept under refrigeration until used or discarded. Analyses of the reversion characteristics of the metaphosphate showed that water dosed with 50 ppm would contain less than 1.5 ppm of reverted metaphosphate at the beginning of any run, and less than 5 ppm after 6 days at the temperature of the experiments. Film deposition studies conducted several hours apart, using the same stock solutions, did not show variations in the rates of deposit, which would be expected if the reverted chemical were the primary source of the deposited material.

The protective films on a few samples were stripped from the metal with acid and analyzed chemically for metaphosphate and orthophosphate content. Approximately 70 per cent of the chemical was found to be present in the form of metaphosphate. As the use of acid radically increases the rate of reversion of metaphosphate, it can be presumed that the ratio of this material in the film was considerably higher than 70 per cent before removal from the metal.

Although both metaphosphates and orthophosphates inhibit corrosion, their characteristics are quite different. Orthophosphates are classified as anodic inhibitors (5, 8). As it has been shown that metaphosphates are cathodic inhibitors (2-4, 6, 11, 12), it follows that the inhibitory action of these chemicals could not logically be presumed to be due to orthophosphate derived from their reversion.

Film Deposition Studies

The purpose of these studies was to investigate the deposition of metaphosphate on the cathodes and anodes

dissipated within a period of 12 hr after the beginning of the run. The rate of flow through the specimen holder was regulated to produce a velocity of 1 fps.

As pickled specimens having an extremely high initial rate of corrosion were employed in this study, it was expedient to use higher concentrations of metaphosphate than those normally employed in practice. Such a procedure may be justified as long as no attempt is made to evaluate the quantitative efficiency of this chemical on the basis of these test results. The many papers by Hateh and Rice have indicated that qualitative results obtained with a 50-

TABLE 1
Composition of Synthetic Tap Water

Chemical	Concentration ppm	Ion Concentration—ppm				
		Mg ⁺⁺	Ca ⁺⁺	Na ⁺	Cl ⁻	HCO ₃ ⁻
MgSO ₄	34.65	7.00				27.65
CaSO ₄	27.09		7.98			19.11
CaCl ₂	39.12		14.12		25.00	
NaHCO ₃	96.30			26.36		69.94
<i>Total</i>		7.00	22.10	26.36	25.00	46.76
						69.94

as a function of time under continuous-flow conditions. Two identical continuous-flow systems were operated in parallel. A synthetic tap water with the composition shown in Table 1 was used in order to prevent variations in the chemical characteristics of the test waters during the different runs, and to maintain an average pH value of approximately 8.0. The total volume of water in each test system amounted to 20 liters. In order to minimize biological activity, the water was dosed with 10 ppm of chlorine at the beginning of each run. The chlorine residual in the test water, was completely

ppm concentration of metaphosphate in the laboratory are comparable to those obtained with concentrations of 2-5 ppm in actual pipelines.

Galvanic cells of steel and stainless steel were used to facilitate analyses of the action of metaphosphate on the individual electrodes of a corrosion cell. The use of stainless-steel cathodes minimized the introduction of foreign metal ions into the test solution. Although the anodes and cathodes were separated by the width of the lucite cell, the action of metaphosphate on the two electrodes of a galvanic cell of this type should be similar qualitatively, but not

quantitatively, to its action on electrodes located on the surface of a single piece of metal, as in a pipe. This concept is correct, provided that the inhibitory action does not involve direct chemical reaction between the inhibitor and the metal to any significant degree, a matter that will be discussed in a later section.

Figure 3 shows the results of two runs made under identical conditions, but in two separate continuous-flow systems, each having 50 ppm of metaphosphate in solution. The curves rep-

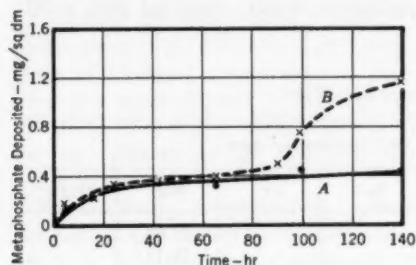


Fig. 3. Metaphosphate Deposition on Cathodes

The curves show the results of two runs made under identical conditions, with 50 ppm metaphosphate in solution.

resent the rate of deposit of metaphosphate on the stainless-steel cathodes of galvanic cells. Values similar to those shown in Curve A of Fig. 3 were obtained in other runs using 20 ppm of metaphosphate instead of 50 ppm, and in runs having widely varying levels of radioactivity in the test solutions. The deposits on the anodes varied erratically and were 20-100 times as great as those on the cathodes. As these very heavy deposits were not obtained in other tests using platinum anodes in impressed-current cells, it is

felt that their presence may be attributed to adsorption or reaction between the metaphosphate and the corrosion products on the anodes. Subsequent polarization studies (11) showed conclusively that the smaller deposits on the cathodes were responsible for the inhibitory action of the metaphosphate. For this reason, only cathode film formation will be discussed in this paper.

From the curves in Fig. 3, it may be seen that the amounts of metaphosphate deposited on the cathodes were extremely small, possibly approaching a

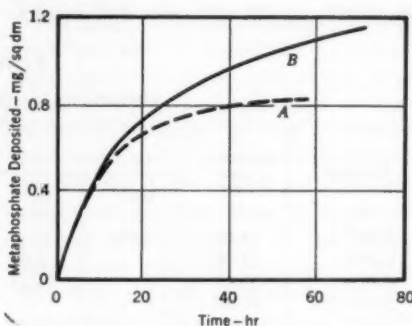


Fig. 4. Metaphosphate Deposition (Reused Water)

Water from the runs in Fig. 3 was reused with new specimens.

layer only one molecule in thickness. There is no way of actually determining whether these amounts represent monolayers, because the exact composition of the deposited material is unknown. The radiochemical analyses were so sensitive that they permitted accurate measurement of the amounts of film on the cathodes of the test cells even though the presence of these films could not be detected visually.

It is evident that similar curves were obtained for the first 80 hr of the two

runs depicted in Fig. 3. After that there was a significant increase in the rate of deposit in the run represented by Curve *B*. All of the specimens used in the two runs were prepared at the same time and under identical conditions. Therefore, it was concluded that the difference in the rates of deposit in the last hours of the runs was probably due to differences in the corrosive waters rather than in the character of the specimens. Analyses of the corrosive waters at the conclusion of the two runs revealed no significant difference in their chemical composition, with the exception of iron concentration. In the water from the run represented by Curve *B*, there was 0.06 ppm of iron in solution, as opposed to an iron concentration of 0.03 ppm in the Curve *A* water.

A second set of fresh specimens was placed in the specimen holders, and the runs were repeated, in part, using the same waters that had been employed for the two runs in Fig. 3. Curves *A* and *B* in Fig. 4 correspond, respectively, to the runs made reusing the waters from the runs of Curves *A* and *B* of Fig. 3.

It can be seen that the reuse of the corrosive waters resulted in much higher rates of deposition of metaphosphate on the cathodes, and a greater total deposit was obtained. The presence of a film on the cathodes in these runs could be detected visually through the formation of interference colors on the specimens. It was evident that the inhibitory action of the metaphosphate was exerted more rapidly in the second runs, as there were no visible deposits of corrosion products on the anodes, even in the early hours of the runs. In the preceding runs, the anodes

had been heavily coated with corrosion products.

The only detectable difference in the conditions under which the first and second sets of runs were made was the presence of corrosion products in solution at the beginning of the second set of runs. Therefore, it was concluded that these corrosion products might have been responsible for the higher rates of deposition in the runs of Fig. 4. In that event, the protective films formed on the cathodes must have been composed of metaphosphate, corrosion products, and possibly other chemicals in solution in the water. Thus, the amount of metaphosphate deposit would not present a true picture of the amount of film present on an electrode, because the metaphosphate would be only one constituent of the film.

Galvanic-Current Studies

The differences between the curves in Fig. 3 and those in Fig. 4 indicated a possibility that corrosion products in the water might exert a significant effect on the action of metaphosphate. The next step in this investigation, then, was to determine the effect, if any, of corrosion products in solution on the inhibitory action of metaphosphate glass, as measured by the current flow in galvanic cells.

In addition to the equipment described previously, a "zero resistance" ammeter (8) was used in these studies. This device permitted the measurement of short-circuit currents between the electrodes of the galvanic cells. This procedure was necessary because a microammeter in the circuit between the electrodes, even though of low resistance, could have a serious effect on the total current flow in the

galvanic cell. In order to measure the galvanic current between the electrodes in each of the couples, the wire that normally short-circuited the cell was disconnected. The two electrodes were then connected to the zero resistance ammeter, and the short-circuit current was determined. The cells were short-circuited again immediately after measuring the current flow.

In the first pair of runs, with the two continuous-flow systems operated in parallel, 0.5 ppm of iron powder was added to the water in System 1, and no iron was added to System 2. In a second pair of parallel runs, 0.5 ppm of iron powder was added to the water in System 2, and none to System 1. This procedure was followed in order to eliminate any possible variations in the operating characteristics of the two separate systems. By adding the iron in the form of powder, it subsequently entered solution in the same manner as when entering from the face of a corroding metal. The iron and 50 ppm of metaphosphate were added to the synthetic tap water 24 hr before beginning the runs.

Each of the curves in Fig. 5 represents the average of the results of two corresponding runs made in the two continuous-flow systems. The curves for the individual runs, obtained by averaging the current flow measurements from the several galvanic cells in each system, showed the same trends as the average curves presented in Fig. 5.

These curves reveal that the addition of iron powder to the corrosive water had a beneficial effect on the inhibitory action of the metaphosphate. It is significant that, toward the end of the runs, the curve representing the current flow in the systems with no iron added tends to approach the curve for

the systems with iron. An explanation is that continued corrosion of the specimens resulted in the further addition of corrosion products to the solution. Separate studies were conducted to determine the effects of metaphosphate and corrosion products on anode and cathode potentials and polarization in galvanic cells (11). From these studies, it was possible to show that the beneficial effect of corrosion products was due to increased polarization of the cathodes of the corrosion cells.

In the light of the film deposition, current flow, and polarization studies,

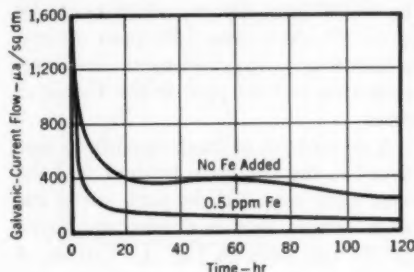


Fig. 5. Effect of Iron on Galvanic-Current Flow Inhibition by Metaphosphate

The solutions contained 50 ppm (NaPO_3)₂. Iron was added in powder form.

it may be concluded that corrosion products in solution have a beneficial effect on the inhibitory action of metaphosphate glasses—an effect which may be attributed to increased deposition of metaphosphate on the cathode and a resulting increase in the degree of polarization of this electrode.

Theory of Mechanism

It is the purpose of this section to develop a reasonable hypothesis concerning the mechanism by which meta-

phosphates inhibit the corrosion of iron in water. This hypothesis will be based on the results obtained in the research described above, taking into account the known characteristics of metaphosphates, as determined by past investigators.

Metaphosphate has been classified as an anodic inhibitor (5, 12, 13) and as a cathodic inhibitor (2-4, 14). Through polarization studies, it has been possible to show that the inhibitor may be made to act in either manner in short-term laboratory tests (11). The results indicated that the mode of action of the inhibitor was affected greatly by the presence of corrosion products in solution, and it was concluded that metaphosphate should be classed as a cathodic inhibitor under practical operating conditions.

Metaphosphate glasses of the type employed in these studies form negatively charged particles when placed in solution in distilled water. Heavy deposits of metaphosphate were observed on the anodes in the course of the studies reported above. The presence of these deposits can probably be attributed to the dual effects of electrical attraction of the negatively charged metaphosphate to the anodic areas and subsequent adsorption or reaction between metaphosphate and the corrosion products on the metal.

Hatch (4) has suggested that electrodeposition is involved in the formation of the cathode film. It is evident that some of the metaphosphate in solution must form positively charged complex ions or colloids before electrical attraction to the cathodes takes place. The presence of trivalent cations in solution would favor the formation of these particles. It has been shown that corrosion products exert a significant

effect on the amount of metaphosphate deposited on the cathode.

Hazel (15) has demonstrated that hydrous ferric oxide and sodium metaphosphate glass may form stable positive or negative sols, or they may coagulate, depending upon the relative amounts of the reacting substances in solution. The data indicated that the formation of positively charged colloidal particles was favored by reduction in pH and increase in the iron oxide-metaphosphate ratio. During the present investigation, qualitatively similar results were obtained with metaphosphate dosages of 4-50 ppm and iron concentrations of 1-50 ppm (16). It is well known that metaphosphate will remove corrosion products from iron. At the anode, where this reaction takes place, the ratio of ferric oxide to metaphosphate is high, and the pH of the solution is at a minimum. Both of these conditions favor the formation of positively charged colloidal particles.

Consideration of the results obtained in this research, together with those obtained by past investigators, has led to the development of the following hypothesis concerning the possible mechanism of corrosion inhibition by metaphosphate glasses: Metaphosphate in solution reacts with the corrosion products in the vicinity of the anodes, resulting in the formation of positively charged colloidal particles. These particles, containing iron oxides and metaphosphate, are subsequently deposited on the cathodes through electrodeposition. The film thus formed decreases the rate of corrosion of iron in water by increasing the degree of polarization of the cathodes in the corrosion cells.

The studies in the latter phase of this research project were conducted with

the objective of determining whether the preceding hypothesis could be substantiated by experimental observations.

Effect of pH on Film Deposition

It has been pointed out that the electrodeposition of a cathode film must depend upon the formation of positively charged particles. It has been shown

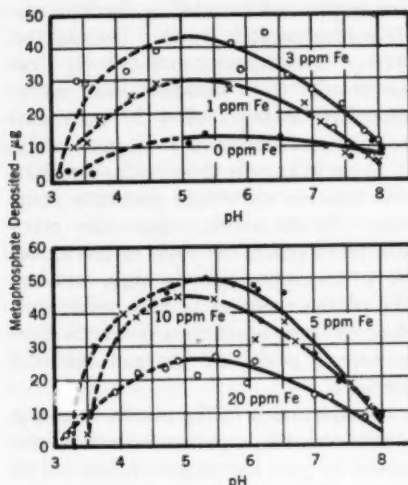


Fig. 6. Effect of pH on Metaphosphate Deposition

Test conditions: 50 ppm (NaPO_3)_x; pH adjusted with HCl; current flow, 1 ma; platinum cathode; iron added as FeCl_2 ; length of test, 1½ hr.

that iron and metaphosphate are capable of forming colloidal particles in tap water (15, 16). The experiments in this section were undertaken for the purpose of investigating the effect of solution pH on the deposition of metaphosphate on the cathode.

The basic equipment used in these tests consisted of a container made

of U-shaped lucite sections, fastened together by means of bolts passing through the entire unit. To eliminate contamination of the test solutions through corrosion of the electrodes, they were made of platinum. A sheet of platinum, which served as the anode, was placed between the lucite sections at one end of the unit. Platinum-covered stainless steel, turned to 0.900-in. diameter and 0.25-in. thickness to fit the available counting equipment, served as the cathode. The latter was screwed to a brass holder, and all metallic surfaces, except for the platinum, were waterproofed.

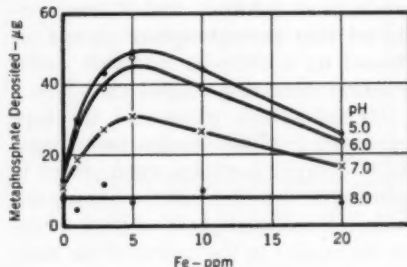


Fig. 7. Effect of Iron Concentration on Metaphosphate Deposition

Test conditions were as in Fig. 6.

Radioactive metaphosphate glass to make 50 ppm was added to 500 ml of synthetic tap water, and the pH of the solution was adjusted roughly with hydrochloric acid. The desired amount of iron was then added to the solution in the form of ferrous chloride. After 30 min of aeration the exact pH of the solution was measured, and a 180-ml sample was placed in the lucite container. This water was agitated by a laboratory stirring machine operated at a uniform speed. A constant current of 1 ma was passed

between the electrodes. One-milliliter samples of the test water were evaporated and counted in triplicate, to determine the number of counts per second per milligram of metaphosphate. At the end of $1\frac{1}{2}$ hr the cathode assembly was taken from the unit and rinsed slightly in distilled water to remove any radioactive test solution adhering to the metal. The cathode was then separated from the brass holder, placed in a counting cup, and counted three times. The amount of metaphosphate on the cathode was determined by the radiochemical techniques previously outlined.

In Fig. 6, the results have been presented in two groups of curves for the sake of clarity. It will be noted that, in the absence of iron, the pH of the solution, at values greater than 5.0, had very little effect on the amount of metaphosphate deposited on the cathode. The decrease in the amount of deposit at lower pH values cannot be explained satisfactorily at this time. In all solutions containing iron, the amount of deposit increased with a decrease in pH to approximately 5.0. The decrease in the amount of deposit at pH values less than 5.0 can possibly be attributed to the increasing solubility of iron. Decreasing the pH below 3.5 appeared to eliminate formation of colloidal particles, as indicated by the absence of Tyndall cones in these solutions.

Colloidal particles of iron and metaphosphate may carry net positive or negative charges. It has been well established by many investigators that the formation of a positive sol is favored by reduction in the pH of the solution. The curves in Fig. 6 show that the deposition of metaphosphate on the cathode is favored by reduction

in the pH of the solution to a value of approximately 5.0. Therefore, these results are compatible with the hypothesis that the cathode film may be formed through the deposition of positively charged colloidal particles on this electrode.

Effect of Iron on Film Deposition

The curves in Fig. 7, plotted from data in Fig. 6, reveal that the addition of iron to the test water had a significant effect on the amounts of metaphosphate deposited on the cathodes, in $1\frac{1}{2}$ hr, at pH 5.0, 6.0, and 7.0. An increase in iron concentration to approximately 5 ppm resulted in a sharp increase in the amount of deposit. This increase can be attributed to deposition of the greater number of positively charged particles on the cathodes. A subsequent increase in iron concentration resulted in a decrease in the amount of deposit, which may be attributed to one or both of the following factors: [1] increased ferric oxide-metaphosphate ratio in the particles, resulting in a decrease in the quantity of metaphosphate deposited; and [2] increased size of the particles, resulting in a lower migration velocity in an electrical field.

It will be noted that the increase in iron concentration had little or no effect on the amount of metaphosphate deposited at a pH of 8.0. The formation of positively charged colloidal particles is inhibited by a rise in pH. Therefore, it may be concluded that, at this pH, the hydrous ferric oxide and metaphosphate did not combine to form a significant number of positively charged particles. On the other hand, in the earlier phases of this investigation (Fig. 3 and 4), it was found that the addition of small quantities of cor-

rosion products to the solution at this pH did have a significant effect on the deposit of metaphosphate. This indicates that the removal of corrosion products by metaphosphate is more effective in producing positively charged colloidal particles than is the reaction between metaphosphate and iron added to the solution in chemical form.

The high ferric oxide-metaphosphate ratio and minimum pH in the vicinity of the anode favor the formation of colloidal particles with net positive electrostatic charges, even though conditions in the solution proper might be unfavorable to the formation of such particles. Furthermore, it has been found (17) that metaphosphate glass forms very highly hydrated particles in water. Therefore, colloidal particles containing hydrous ferric oxide and metaphosphate are probably highly hydrated. This hydration shell interferes with or retards reaction between a particle, once formed, and other particles in solution. Hence, a particle formed at the anode of a corrosion cell would have a tendency to retain its net positive charge, although conditions in the solution proper might be unfavorable to the formation or continued existence of such a particle.

The curves in Fig. 7 show that a deposit of metaphosphate was obtained on the cathode in the absence of iron. It has been found that this deposit can be attributed to the effect of calcium in solution (18).

Deposition of Corrosion Products in Cathode Film

It has been shown that the addition of corrosion products to the solution increases the amount of metaphosphate deposited on the cathode. It was the purpose of the experiment described in

this section to determine whether a transfer of corrosion products from anode to cathode, as postulated in the hypothesis, actually takes place.

An iron-plating bath containing ferrous chloride and calcium chloride was prepared. Approximately 75 microcuries of radioactive iron (Fe^{55-59}) was added to this solution. Steel specimens were pickled thoroughly and placed in the plating solution. A current with a density of approximately 100 amp per square foot of specimen area was passed between the submerged specimens. After removal from the plating bath, the radioactive cathode was washed thoroughly with tap and distilled water.

This electrode was then used as the anode in an impressed-current cell. A platinum electrode, identical with those employed in preceding tests, was used as the cathode of the corrosion cell. The electrodes were immersed in 500 ml of synthetic tap water containing 50 ppm of nonradioactive metaphosphate glass, and a current of 1 ma was passed between them. The solution was agitated by means of a laboratory stirrer. A platinum electrode through which no electrical current passed served as a control specimen. The platinum electrodes were removed, rinsed in distilled water, and counted at the end of $1\frac{1}{2}$ hr.

On the basis of three runs, the platinum cathode showed the presence of a significant amount of radioactive deposit at the end of the above procedure (1.33 counts per second). The control specimen, through which no electrical current passed, showed the presence of very little radioactivity above background. The only source of radioactive material in this test was the iron anode. Therefore, the presence of a

radioactive deposit on the platinum cathode can only be attributed to the transfer of material from the anode to the cathode of the corrosion cell, thus substantiating the hypothesis that the cathode film contains corrosion products in addition to metaphosphate. Another inference is that it is not necessary to add iron to the water in order to cause the deposit of a cathode film containing iron. A source of this metal is made available in the corrosion process.

The presence of a relatively large deposit on the cathode in the impressed-

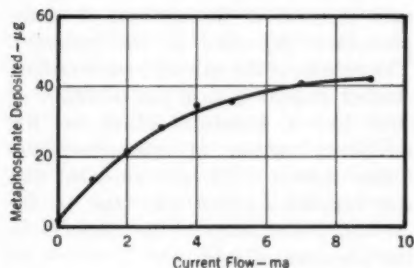


Fig. 8. Effect of Electrical-Current Flow on Metaphosphate Deposition

Test conditions: 50 ppm (NaPO_3)₃; 20 ppm Fe (FeCl_2); pH 7.7.

current cell, and a very small deposit on the control specimen, is consistent with the hypothesis that electrodeposition is the primary mechanism in the formation of the cathode film.

Role of Electrical-Current Flow in Film Deposition

This section of the investigation was undertaken to determine whether cathode film formation is a function of the electrical current flowing through the cell. The equipment used in these studies was identical with that in the

investigation of the effects of pH on film deposition.

A synthetic tap water solution containing 50 ppm of radioactive metaphosphate glass and 20 ppm of iron, in the form of ferrous chloride, was aerated for 30 min, and 180 ml of this water was added to each lucite container. The rate of electrical-current flow through each unit was adjusted to a desired constant value. The water was stirred continuously throughout the tests, as in the studies on the effect of pH. One-milliliter samples of the water were evaporated and counted to determine the counts per second per milligram of metaphosphate in solution. At the end of 1½ hr the platinum-faced cathodes were removed. The amount of metaphosphate deposited on each was determined by counting the specimens with the films in place. Duplicate runs were made and the results averaged for presentation in Fig. 8.

Figure 8 reveals that the rate of current flow had a marked effect on the amount of metaphosphate deposited on the cathode. Very little deposit was obtained in the absence of electrical current, and the small amount that was deposited can probably be attributed to adsorption of the chemicals on the metal. The increase in the amount of deposit with increase in current flow can be attributed to one of two factors: [1] reaction between the metaphosphate and cathodic products, causing deposition of this chemical on the cathode; or [2] electrodeposition of the metaphosphate.

To distinguish between these alternatives, it should be recalled that alkalinity is produced at the cathode, causing a rise in pH in the vicinity of this electrode (5, 8, 9). In the phase of this investigation dealing with the effects

of pH, it was shown that a rise in pH could be expected to result in a smaller cathode deposit. From this fact, it is evident that the increase in deposit with increased current flow occurred in spite of the alkalinity formed at the cathode rather than because of it. Consequently, it must be concluded that the cathode film of metaphosphate and corrosion products is formed through electrodeposition, thus confirming a portion of the hypothesis previously outlined.

Evaluation

Hatch (4) has suggested the possibility that the calcium salt or complex of metaphosphate glass may form positively charged colloidal particles in solution. On the other hand, Reitemeier and Buehrer (19) concluded that colloidal particles of calcium and metaphosphate were not formed, even in supersaturated solutions of calcium carbonate. It should be pointed out, however, that this conclusion was based on the absence of a Tyndall cone in such solutions, a condition that does not necessarily preclude the possibility of a colloidal suspension.

It is well known that metaphosphate exists in the form of a negatively charged particle in distilled water. In this investigation, no significant deposit of metaphosphate was found on platinum cathodes immersed in distilled water containing metaphosphate. All migration of metaphosphate under these conditions was in the direction of the anode. In waters containing calcium, significant deposits of metaphosphate were found on the platinum cathodes (Fig. 6 and 7). Therefore, it may be concluded that calcium and metaphosphate combine to form positively charged particles. No conclusion can

be reached, however, as to whether these particles are ionic or colloidal in nature, as no Tyndall cones were observed in these samples. Previous studies (11) showed that, when metaphosphate was deposited on the cathode in the absence of iron, it had little or no effect on the polarization of this electrode. Therefore, the inhibitory action of metaphosphate glass cannot be attributed solely to this deposit.

In the film deposition studies and in the section dealing with the effect of iron on film formation, it was found that the presence of a small amount of iron in the water resulted in a significant increase in the amount of metaphosphate deposited on the cathodes. The results of the galvanic-current flow studies indicated that the addition of iron had a beneficial effect on the inhibitory action of metaphosphate. Other studies (11) have revealed that the beneficial effect was due to increased polarization of the cathodes in the presence of iron.

Metaphosphates remove corrosion products from the anodes of corrosion cells. At these locations are found the conditions of low pH and high iron concentration that are most favorable to the formation of positively charged colloidal particles of metaphosphate and hydrous ferric oxide. The study of the deposition of corrosion products in the cathode film showed that a transfer of corrosion products from anode to cathode actually took place. These results confirm the hypothesis that metaphosphate and hydrous ferric oxides are constituents of the protective film. The corrosion products removed from the anodes by metaphosphate may be considered a source of the oxide which is subsequently deposited on the cathodes in combination with the metaphosphate.

The investigation has shown that the protective film is formed on the cathodes primarily through a process of electrodeposition. This conclusion is in agreement with the findings of Hatch (4) and is consistent with a theory of cathode film formation through electrodeposition of positively charged colloidal particles containing metaphosphate and hydrous ferric oxides.

It was found that a decrease in pH to approximately 5.0 resulted in an increase in cathode film deposition. A further decrease in pH resulted in a sharp decrease in film formation. It has been pointed out that these effects are consistent with the theory of colloidal action which has been developed. A decrease in pH might be expected to result in the formation of a greater number of positively charged colloidal particles (or more highly charged particles). The decrease in film formation at lower pH may be attributed to the increased solubility of iron. These results are in agreement with those of Hatch and Rice (1), who found that the inhibitory action in metaphosphate-treated water appeared to be more pronounced as the pH decreased to approximately 5.0. They also found that the inhibitory action decreased at pH values less than 5.0.

It should be pointed out that the findings of this investigation do not negate or conflict with the results obtained by most previous investigators. Rather, an explanation of the mechanism underlying their findings has been disclosed. This makes possible a direct correlation between the present findings and those of past investigators. The new information brought to light during these studies may be used to explain conflicting or incon-

sistent results reported by some investigators.

Conclusions

The results obtained in this research work lead to the following conclusions about the inhibitory action of metaphosphate glass on the corrosion of iron in water:

1. Metaphosphate glass, when added to solution in sufficient quantity, will remove corrosion products from the anodes of corrosion cells.

2. In the vicinity of the anodes of corrosion cells, there is a high ferric oxide-metaphosphate ratio and a minimum pH. These conditions are favorable to the formation of positively charged colloidal particles of hydrous ferric oxide and metaphosphate.

3. The rate of deposition of metaphosphate on cathodic areas, as well as its inhibitory action, is enhanced by the presence of corrosion products in solution.

4. Some of the corrosion products stripped from anodes by metaphosphate are subsequently deposited on the cathodes.

5. The protective film formed on the cathode contains colloidal particles made up of metaphosphate, ferric oxide, and other chemicals deposited from solution.

6. The protective film is deposited on the cathode through a process of electrodeposition.

7. The protective film reduces the rate of corrosion by increasing the degree of polarization of the cathode.

8. The rate of deposition of metaphosphate on cathodes is highest at a pH of 5.0 and decreases above and below this pH value.

9. The rate of deposition of metaphosphate on cathodes increases with

an increase in iron concentration in the water up to a limiting value.

Acknowledgment

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Mechanism and Control of Scale Formation in Sea Water Distillation

By **W. F. Langelier**

A contribution to the Journal by W. F. Langelier, Prof. of San. Eng., Univ. of California, Berkeley, Calif.

IN 1941, when the military services accepted engine-driven compression equipment for the distillation of sea water, serious problems in the control of evaporator scale deposits were quickly brought to light, and several investigations were initiated in an endeavor to solve these difficulties. This paper describes briefly some of the conclusions derived from a research project recently completed by the Institute of Engineering Research at the University of California, Berkeley, Calif.

The project involved extensive laboratory studies in the chemistry of evaporator deposits and also the full-scale operation of a standard 60-gph thermocompression still supplied with water from San Francisco Bay. The project was sponsored by and received the intimate cooperation of the Sanitary Engineering Branch, US Army Corps of Engineers, Fort Belvoir, Va.

No simple theory is completely adequate to explain all of the manifestations and apparent contradictions associated with scale formation in the distillation of sea waters. Just when it appears that all possible deviations from normal have been accounted for, a new and challenging situation arises to confound the investigator. With full-strength untreated sea water, a unit may operate for as long as 600 hr

between descalings, whereas, with diluted harbor water, the same unit may operate for only 200 hr. A unit that develops magnesium hydroxide scale when operated at one location on the Atlantic Ocean is found to develop calcium carbonate scale when operated at another. These and other apparent inconsistencies have been observed. A few generalizations can, however, be made:

1. The avoidance of hard sulfate scale requires that the sea water should not be concentrated to less than one-third of its original volume—that is, the concentration factor should not exceed 3.0. This is accomplished by controlling the blowdown rate so that it does not fall below 33 per cent of the rate of feed.

2. Operating as in the preceding paragraph, the scaling potential of sea water is normally a function of total alkalinity, but silica, when present in significant amounts, either as turbidity or in solution, exerts an unfavorable effect disproportionate to its concentration. Coastal and harbor waters may differ from normal sea water in these respects.

3. The dry weight of scale deposited within a given interval is roughly equivalent to the total alkalinity in the volume of water distilled. Depending

upon the composition of the scale, its weight may vary between approximately 0.5 and 1.0 lb per 1,000 gal of distillate.

4. Magnesium hydroxide is normally the predominant scale component if boiling occurs at atmospheric pressure or higher, but calcium carbonate may predominate if boiling occurs at lower temperatures, as in vacuum distillation.

Stability Concept of Scale Formation

There is a widely accepted theory that the formation of scale in a boiler or evaporator is always due to the presence of salts, the solubility of which decreases with temperature rise, and that a sludge or dispersion always forms under the reverse conditions. This theory is not too convincing, at least when applied to the evaporation of sea water. Because scales or incrustations of similar composition are known to form on surfaces both hotter and colder than the concentrated brine, it must be concluded that the slope of the solubility curve of a scale component is not the determining factor.

An explanation of scale formation which appears to conform more closely to laboratory and plant observations is based upon nucleation phenomena. This concept recognizes that the bulk of the concentrated brine in an evaporator is in a highly supersaturated or metastable state with respect to the principal scale-forming salts (1). The brine that is in contact with a heating surface, as a result of local evaporation, ultimately exceeds a critical metastable solubility limit, and adherent salt crystals deposit spontaneously on the wetted surface at that point. Elsewhere in the brine mass, contact with seed crystals detached from a heating

surface, or the presence of other disturbing factors, can induce precipitation of a portion of the saturation surplus; this portion is not scale forming but tends to remain suspended in the brine or to deposit as sludge. The scale that forms on a heating surface is invariably more dense and compact than that which forms on other surfaces, because, on the former, the growth of scale results in part from salt deposition caused by brine evaporation within the capillary pores of preformed scale.

A simple laboratory experiment can be performed to illustrate the precipitating effect of seed crystals in sea water brine. The experiment consists in filling a new, clean glass beaker with filtered sea water and subjecting it to boiling on a hot plate. A precipitate will not form until approximately half the brine has boiled away. If, after a precipitate has formed, the beaker is emptied, brushed, thoroughly rinsed, and then refilled with some of the original water and resubjected to boiling, a visible precipitate is likely to form before even one-fifth of the brine has evaporated. In this experiment, the brushing has failed to remove some of the microscopic stabilizing seed crystals held within the surface pores of the glass. A similar effect can be produced by adding to the boiling brine a quantity of fine sand or other foreign material that offers an extended contact surface.

Scale Components and Concentration Effects

The most objectionable component of evaporator scale is calcium sulfate, which can precipitate from concentrated brine in either the anhydrous or hydrous form. The true solubility of

the former is reached when the water is concentrated to two-thirds its original volume; but, because of its strong tendency to exist in supersaturated solutions, normal sea water can be concentrated to one-third of its original volume before any appreciable amount of calcium sulfate is formed. This concentration represents the limiting solubility of the hemihydrate, a form that is less resistant to supersaturation.

Unlike calcium sulfate, the precipitation of calcium carbonate and magnesium hydroxide results from causes other than brine concentration alone. The loss of volatile carbon dioxide in the steam increases the concentration of both carbonate and hydroxyl ions in accordance with well known laws of chemical equilibria. Even when there is no carbon dioxide loss, temperature elevation, such as occurs in the flash generation of steam, produces an increase in hydroxyl ion concentration sufficient to cause the formation of scale. The combined effects of carbon dioxide loss and temperature elevation are equivalent to the addition of a strong base to the brine, and precipitation occurs as in water softening.

Effects of Brine Temperature

Laboratory experiments and repeated field observations of sea water distillation indicate that a low boiling temperature favors the precipitation of calcium carbonate, whereas a high boiling temperature favors the precipitation of magnesium hydroxide. In a comprehensive study of scale formation in sea water evaporators, Hillier (2) has noted that the transition temperature is in the vicinity of 180°F, at which the total precipitated solids are at a minimum. There has been considerable speculation about the mecha-

nism of the temperature effect, and further discussion appears warranted.

Under normal conditions in an evaporator at any given temperature, calcium carbonate will precipitate from supersaturated brine when the product of the calcium and carbonate ion concentrations (activities) exceeds a fixed limit, S_c , and magnesium hydroxide will precipitate when the product of the magnesium and the square of the hydroxyl ion concentration exceeds a fixed limit, S_m . The equations can be written:

$$\begin{aligned} [\text{Ca}^{++}] \times [\text{CO}_3^{--}] &= S_c \\ [\text{Mg}^{++}] \times [\text{OH}^-]^2 &= S_m \end{aligned}$$

In these equations, the brackets indicate molal concentrations of the respective ion species, and the S values are the respective supersolubility product constants for the metastable brine. The S values are unknown, but there are reasons for believing that, in the absence of abnormal catalytic effects, their use in the above equations is valid. The equations indicate that, at any given temperature, the precipitation of calcium carbonate from brine will be favored by increases in the ratio of either $[\text{Ca}^{++}]$ to $[\text{Mg}^{++}]$ or $[\text{CO}_3^{--}]$ to $[\text{OH}^-]^2$, and the precipitation of magnesium hydroxide will be favored by decreases in these ratios. In sea water brines, the ratio of $[\text{Ca}^{++}]$ to $[\text{Mg}^{++}]$ remains reasonably constant during evaporation, and, therefore, at any fixed temperature, the ratio of $[\text{CO}_3^{--}]$ to $[\text{OH}^-]^2$ becomes a critical factor in determining which of the two salts is favored for precipitation. This ratio is not readily measured, but an estimate of its value at given temperature can be made by substituting $\frac{k_2[\text{HCO}_3^-]}{[\text{H}^+]}$ for $[\text{CO}_3^{--}]$ and $\frac{k_w^2}{[\text{H}^+]^2}$

for $[\text{OH}^-]^2$. This gives:

$$\frac{[\text{CO}_3^{--}]}{[\text{OH}^-]^2} = \frac{k_2 [\text{HCO}_3^-] \times [\text{H}^+]}{k_w^2}$$

In this equation k_2 is the second dissociation constant for carbonic acid and k_w is the dissociation constant for water. It is well known that the dissociation constant of water increases greatly with temperature. Actually the value of k_w^2 is known to increase approximately 10,000 times between the temperatures

precipitation of magnesium hydroxide above 180°F. The precipitation zones of calcium carbonate and magnesium hydroxide are shown as functions of brine concentration and temperature in Fig. 1.

Scale Control Measures

The stability concept of the mechanism of scale formation and evaporator deposits is believed to be of value in explaining the merits of certain old and new practices in the art of scale control. The concept suggests that supersaturation which is relieved by evaporation at a heating surface forms adherent scale, whereas supersaturation, which is relieved by means other than evaporation—for instance, contact with an effective catalyst—forms a dispersion that is discharged in the blow-down. An example of the latter is the use of the well known boiler compounds.

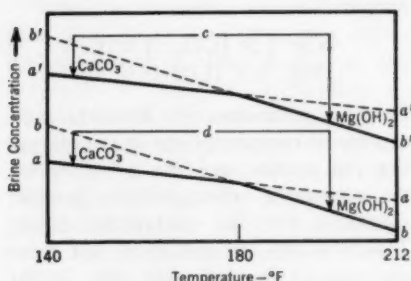


Fig. 1. Precipitation Zones (Schematic)

Key: A-A, solubility curve for calcium carbonate; A'-A', supersolubility curve for calcium carbonate; B-B, solubility curve for magnesium hydroxide; B'-B', supersolubility curve for magnesium hydroxide; C, transgression occurs at heating surface, causing immediate precipitation as scale; D, transgression occurs apart from heating surface, causing delayed precipitation, hastened in presence of nucleating agent.

of 70° and 212°F. Accordingly, the carbonate-hydroxide ratio is very sensitive to temperature change, a fact that probably explains the normal gradual reduction in calcium carbonate precipitation with increasing temperature between 150° and 180°F, the minimum precipitation of either salt at 180°F, and the gradual rise in the pre-

Boiler Compounds

One of the properties of a good boiler compound is that, by virtue of the colloid which it contains, it is capable of functioning as a nucleating catalyst. Starch and other organic colloids have been widely used for this purpose. In recent years the formulation of boiler additives has been greatly improved by the incorporation of new surface-active and complexing agents (3).

Related to the use of boiler compounds in scale control is the practice of pretreating the feedwater with a heavy-metal hydrolyzing salt, such as ferric chloride or alum. These salts probably serve a dual purpose in that they yield both a strong acid capable of neutralizing alkalinity and an insoluble metal hydroxide capable of reliev-

ing supersaturation by catalysis. Hillier (2) reports that the ocean liners, *Queen Mary* and *Queen Elizabeth*, each reclaiming 200 tons of fresh water per day, now use ferric chloride in their sea water evaporating plants, with very satisfactory results.

Electrochemical Action

The wide variety of chemical additives found to be of value in scale control or in the stabilization of supersaturated solutions suggests that, under properly controlled conditions, the by-products of electrochemical action might be made to serve the purpose more conveniently and more economically. *Devices of the type described below should not be confused with the many fantastic and even fraudulent electrical scale control devices now being sold. The existence of the latter should not obscure the possibilities of legitimate development in this field.*

Recently investigators (4) at the Belgian Center for Study of Corrosion, Brussels, demonstrated the successful use of an electrochemical method of scale control in large-scale distillation of fresh water. The device employed consisted of a corrosion cell of the impressed-current type placed in the feedwater line and operated in such a manner as to yield ferrous hydroxide from sacrificial iron electrodes. A 2-year investigation showed that success with this method was dependent upon proper regulation of the electrode potentials to insure continued corrosion of the anode—that is, the avoidance of passivity. This was accomplished by establishing a daily rest period of several hours during which the electrical circuit was broken. The water used in these tests had an abnor-

mally high pH and a low chloride content. It is not improbable, however, that reported failures of this type of device in other investigations (5) may be ascribed, at least in part, to fouling of the anode surface and inadequate regulation of electrode potentials.*

Sea water is a good conductor of electricity, and its electrolysis, by employing inert electrodes, could be made to yield a soluble acid and an insoluble base, both of which could be expected to serve as stabilizing agents, as in ferric chloride addition.

Electromagnetic and sonic forces are known to exert stabilizing effects upon supersaturated solutions, but chemical literature yields only scant reference to the application of these forces in scale prevention.

Results of Berkeley Study

In the Berkeley study, initial efforts were directed toward finding a scale control method that would be applicable to the distillation of sea water in thermocompression equipment and would function without the addition of chemicals. Several possibilities for accomplishing this objective by the control of rate mechanisms were considered: [1] evaporator modification to secure minimum liquid volume commensurate with distillation rate; [2] operation with highest permissible ratio of blow-down rate to distillation rate; and [3] continuous circulation of metastable evaporator brine through externally located contact media capable of inducing precipitation thereon. The third method seemed to offer the greatest promise and was the first selected for investigation.

* Concerns engaged in the promotion of water treatment devices are specifically forbidden to quote from this paragraph.

Contact Brine Stabilization

The initial tests, both laboratory and full scale, have been described in an earlier paper (1). The results were favorable, but many problems remained to be solved. Most of the development and evaluation work with this process was carried out by the sponsor at the distillation test station at Fort Story, Va. Many variables were investigated and it was demonstrated that, with proper design to suit specific feedwater conditions, the brine stabilization method is capable of prolonging at least tenfold the normal intervals between required descalings.

In its mechanical features, a brine stabilizer resembles an upflow cation-exchange water softener. The hot concentrated brine is circulated at a rate approximately 20 times the distillation rate. Beach sand, because of its wide availability, is used as the contact material. The sand requirement for an average installation is 7 lb per gallon of distillate per hour. The stabilizer shell should have a uniform cross-section area of 1 sq ft per 40 gal of distillate per hour. Allowance for sand expansion during operation requires an overall shell depth of approximately 6 ft. In order to avoid objectionable incrustation and cementation of the supporting gravel with calcium sulfate, it is essential that, in operation, the brine concentration factor should not be allowed to exceed 3.0; preferably, it should not average higher than 2.5. Prior to shutdown, the unit should be flushed with feedwater. Enlargement of the individual sand grains by accretion is compensated for by such losses of material that the total volume of the sand remains approximately constant. The carryover, into the evaporator, of precipitate released from the stabilizer may cause

foaming, but otherwise carryover is desirable as it enhances the stabilizing effect and does not appear to contribute to scale growth.

Evaporator Tube Inserts

During the course of the investigation, considerable attention was given to the possibilities of brine stabilization exclusively within the evaporator. No satisfactory method was evolved, but one of the trials is believed worthy of mention. The insertion of a water-displacing metal rod in each evaporator tube caused the brine to boil in an annular space with an average distance of $\frac{1}{8}$ in. between concentric surfaces. The results were by no means spectacular but experimental runs of several times normal duration were obtained. Considerable sludge accumulated in the bottom of the evaporator, indicating that the beneficial effects were due primarily to greater turbulence and to the scrubbing action exerted upon freshly formed scale. In these experimental runs, a loose, porous scale always formed on the rods.

Citric Acid

It was recognized from the beginning that brine stabilization was not a complete substitute for descaling but rather a method of prolonging the intervals between descalings. If the heating surfaces are wettable and if scale-forming salts are present in the feedwater, scale formation cannot be entirely prevented. In copper alloy evaporators, descaling has been accomplished either mechanically, by drilling, or chemically, by dissolving the scale with inhibited strong acid. There are well known objections and limitations to both methods. In an aluminum alloy evaporator that was under investigation, neither of these methods could

be used, and an effort was made to find a scale solvent that would be nonvolatile, less corrosive, and more safely handled than strong acid. Consideration was therefore given to the possibilities offered by the use of weak organic acids. Laboratory tests and

powder, instantly soluble in less than its own weight of water. Because of its wide use in the food and beverage industries, it is readily available. It can be shipped and stored in fiber drums and is safe to handle. In its scale-dissolving action, it differs materially from hydrochloric and sulfuric acids. Being a weak acid, it exhibits buffer capacity when mixed with its salts in solution. Consequently, even in the event of a large accidental overdose, the solution in the evaporator quickly approaches approximate neutrality. Of equal importance is the fact that the salts of citric acid are sequestering or complexing agents and act in the manner of metaphosphates in solubilizing scale material. This property should assist materially in dissolving scales containing appreciable percentages of calcium sulfate.

Originally conceived as a means of terminal descaling, citric acid was first applied to the evaporator at 250-hr intervals. The ease of application, the short "down" time, and the excellent results obtained suggested its use at shorter intervals to maintain relatively clean tubes, thus confining the steam pressure range to a minimum. It was found that, when applications were made at 48-hr intervals over a total period of 32 days of continuous operation, the steam pressure differential at no time exceeded one-third of the normal operating range. The cumulative distribution of the alkalinity scale potential during this run is shown in Fig. 2.

To simplify the acid cleaning process, the unit was modified to permit discharging both blowdown and distillate into the suction of the feedwater pump. This was accomplished by installing valves and piping as shown in Fig. 3. With this arrangement, it was

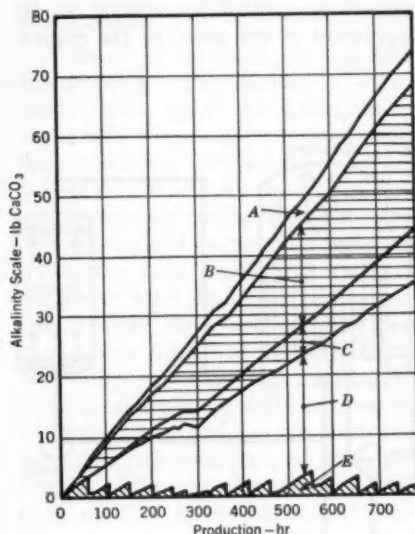


Fig. 2. Cumulative Distribution of Alkalinity Scale Potential

Key: A—distillate; B—blowdown (dissolved alkalinity); C—blowdown (suspended alkalinity); D—retained in evaporator and removed by acid; E—retained in evaporator. Operating data: Alclad 3S evaporator, 60-gph capacity, cleaned with citric acid at approximately 48-hr intervals.

other factors indicated that several of these acids could serve the purpose. Citric acid appeared to offer the greatest promise and was selected for full-scale tests.

Citric acid, now manufactured largely by the fermentation of sugar solutions, is a stable, nontoxic, white

possible to add the calculated quantity of acid to the feedwater intake and circulate the acid solution through every part of the still, including the feedwater pump, blowdown distillate heat exchanger, evaporator, and engine exhaust heat exchanger. By changing the setup so as to divert the distillate directly into the evaporator through the drain opening, the heat exchangers,

flushing at the end of the cleaning cycle. During the cycle the compressor discharge pressure rises to approximately 10 psi. This condition was not found to be a problem, and the increased temperature probably resulted in more rapid action of the acid on the scale. The pressure that develops is subject to control by venting or by regulation of the speed of the engine.

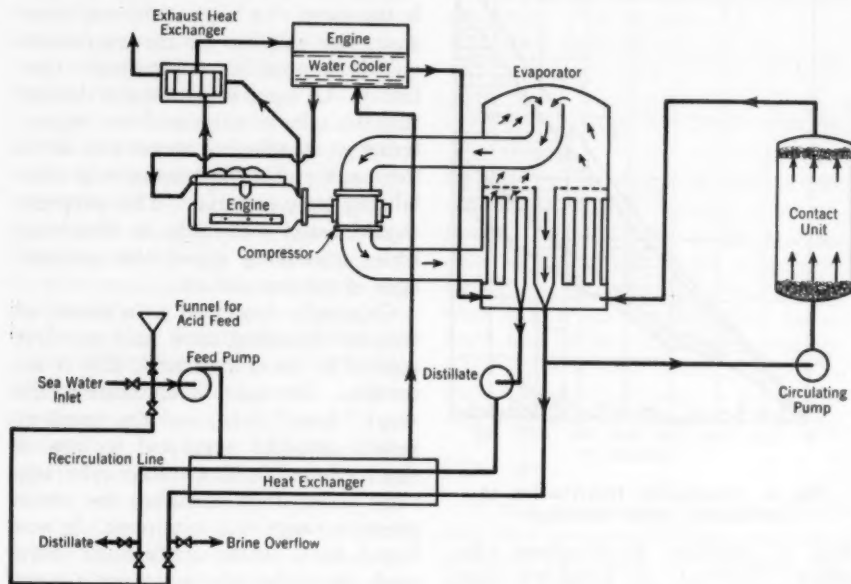


Fig. 3. Distillation Equipment Flow Diagram

This flow diagram of thermodistillation compression equipment shows the connections for scale control by contact brine stabilization and periodic injections of citric acid.

which show only a slight tendency to scale, are bypassed.

The cleaning operation requires a maximum of 45 min down time, including 30 min for acid contact. As the acid used and the salts formed are nonvolatile, nontoxic, and noninjurious to the metal, the unit does not require

The quantity of acid added at each cleaning was calculated from the volume of distillate produced during the interval. It was found that approximately 1½ lb of citric acid, obtainable at a cost of 40 cents, was required for each 1,000 gal of distillate. Further investigation is needed to determine

the optimum time interval between acid applications.

The results of several test runs indicate that the method is effective and practical, particularly for small military installations or where space considerations would limit the use of the brine stabilization method.

Conclusions

A theory of the mechanism of scale formation in water distillation equipment, based upon the principles of nucleation from supersaturated solutions, conforms more nearly to experimental data than does the widely held temperature-difference solubility theory. Because of evaporation occurring within the scale capillary pores, scale due to self-nucleation on a heating surface is more dense and compact than that which forms on other surfaces. Nucleation resulting from catalytic effects, apart from the walls and heating surfaces, forms a dispersion and does not appear to contribute to scale formation. Many of the chemical additives used in scale control owe their efficiency, in part, to this type of nucleation.

Two methods of scale control applicable to sea water distillation—external brine stabilization and daily or alternate-day dosing with citric acid—have been described. The latter method is indicated for installations of

limited capacity, but, for large installations, the combination of external brine stabilization with daily cleaning of the evaporator by the addition of a suitable acid should prove most economical and should permit operation of compression distillation equipment with complete safety and maximum efficiency. By eliminating the necessity for mechanical descaling and by safely confining the variations in steam pressure to within one-third or one-fourth of the present allowance in compression distillation, these methods afford the manufacturer of new equipment several attractive possibilities of effecting economies in distillation by employing design features heretofore regarded as impractical.

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Use of Ion-Exchange Methods in Water Analysis

By Calvin Calmon

A contribution to the Journal by Calvin Calmon, Head, Chem. Lab., Research Div., The Permutit Co., Birmingham, N.J.

ION exchangers are fast becoming a standard tool in analytical chemistry. Their use in water analysis has been reported in numerous publications. The aim of this paper is to summarize the work thus far done in the field, to indicate the possibilities and limitations of the methods, and to give additional data on some of the procedures.

The use of ion exchangers as an analytical tool has been described by Samuelson (1), Rieman (2), Kunin and Myers (3), Walton (4), and Kunin in his yearly reviews in *Analytical Chemistry*. Ion exchangers may be employed analytically for: [1] concentration of trace quantities of components present in water; [2] removal of interfering ions or impurities; [3] replacement of one ion by another that is more easily analyzed; [4] chromatographic separation; and [5] direct concentration or endpoint indication. Before these uses are discussed and illustrated, it is well to give a short description of the present commercial ion exchangers and their properties.

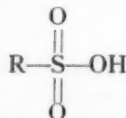
Structures and Properties

The unit structure of an ion exchanger may be written $R-G-X$, R being the matrix of the resin or the polymeric part, G the active group possessing the exchange property, and X the exchangeable or mobile ion. A cation exchanger is one in which $R-G$

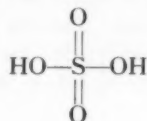
is negatively charged and X is a cation, and an anion exchanger is one in which $R-G$ is positively charged and X is an anion. In cation exchangers, the active group (G) may be sulfonic ($-SO_3-$), carboxylic ($-COO-$), or phosphonic ($-PO_2O-$). The anion exchangers have amines as their active groups, primary ($-NH_2$), secondary ($=NH$), tertiary ($\equiv N$) or quaternary ($\equiv N-$).

Cation Exchangers

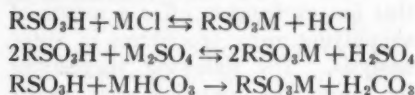
Ion exchangers may be looked upon as solid electrolytes, and the laws governing electrolytes may be applied to the exchangers, except that their solid nature must be taken into consideration. Also, like the soluble electrolytes, the ion exchangers are divided into two main groups, the strongly and weakly dissociated types. Thus, the sulfonated copolymers of styrene and divinyl benzene in the hydrogen form:



may be looked upon as sulfuric acid:

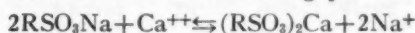


with one OH replaced by R. The R makes the whole system fixed, except for the remaining H ion, which is mobile and exchangeable. An exchanger of this type in the hydrogen form will go through the following reactions in contact with various salts:



Thus, the salt in the solution is converted to the corresponding acid, and the ion exchanger to the salt form.

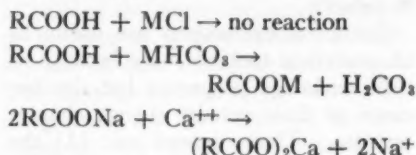
Divalent ions are preferentially taken up by the cation exchanger. If an exchanger is in the sodium state, it will exchange the sodium for calcium and magnesium so that the effluent will contain only sodium salts. This reaction is the usual softening process:



Thus, the salts present in the water can be converted to the corresponding acids if the exchanger is in the hydrogen form, and the hardness can be changed from calcium or magnesium to sodium if the cation exchanger is in the sodium form. The exchangers may be regenerated to any salt form or to the hydrogen state by the use of concentrated solutions containing the corresponding ions.

The carboxylic acid resin in the hydrogen form will not split neutral salts like NaCl and CaSO_4 to form the corresponding acid. The carboxylic acid group makes the exchanger a weak electrolyte, so that the reaction favors keeping the exchanger in the hydrogen form, unless the anion in the solution is that of an acid weaker than the carboxylic exchanger. When a bicarbonate solution is passed through the exchanger, the cation is exchanged for hydrogen because the carbonic acid formed is weaker than the carboxylic

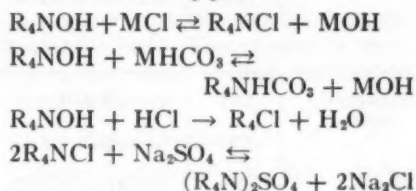
acid. A carboxylic exchanger in the sodium form is selective for divalent ions. The behavior of the carboxylic acid exchangers may be summarized in three equations:



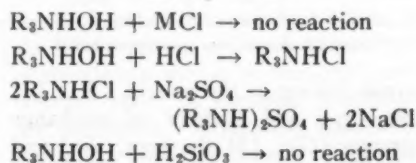
Anion Exchangers

The anion exchangers likewise include strongly and weakly basic types. Their reactions are similar to those involving cation exchangers, except that there is an exchange of anions. The direction of exchange depends on the same chemical laws as for the cation exchangers. From the equations given below, the behavior of and differences between the two types of anion exchangers are self-evident:

strongly basic



weakly basic



The strongly basic anion exchangers will react with both strongly and weakly dissociated acids, but weakly basic anion exchangers will react only with strong acids, such as HCl and H_2SO_4 , and not with weak acids like

H_2CO_3 and H_2SiO_3 . The direction of an exchange reaction depends on the selectivity of the exchanger, which, in turn, depends on the type, size, valence, and concentration of the particular ion in solution.

Some ion exchangers are useful as an analytical tool not only because of their exchange properties but also because of their volume change characteristics. These depend on: [1] the type of exchanger and the degree of

them and is an indicator of the valence of the ions in the exchange position as well as of the solvent dielectric.

General Techniques

From the numerous examples given later in this paper, it will be evident that ion exchangers offer a means of simplifying many procedures in water analysis. The following suggestions for using the materials may prove helpful.

TABLE 1
Conditioning of Ion Exchangers for Analytical Procedures

Exchanger	Desired Form	Reagent	Frees Exchanger From	Reagent Strength per cent	Exchanger Rinsed to pH
Cation Exchangers					
Strongly acidic	H	HCl	metallic cations	10	over 4.4
	Na	NaCl	H or other ions	10-15	over 4.4
Weakly acidic	H	HCl	metallic cations	5	approx. 4.3
	Na	HCl-rinse-NaOH	*	5	approx. 8.3
Anion Exchangers					
Strongly basic	OH	NaOH	other anions	5	under 8.3
	Cl	HCl	other anions	5	over 4.4
Weakly basic	OH	NaOH or Na_2CO_3	other anions	5	approx. 8.3
	Cl	HCl	other anions	3	approx. 4.3

* Slow diffusion requires long contact period.

cross linking in the matrix (R); [2] the type and number of exchange groups (G); [3] the type, size, and valence of the mobile ion (X); [4] the type and concentration of the electrolyte in contact with the exchanger; and [5] the type and concentration of the solvent. For some exchangers, the volume is a direct measure of the electrolyte concentration in contact with

Conditioning of Exchanger

Most commercial cation exchangers may contain traces of impurities that should be removed prior to use in analytical work. The exchanger should be left in contact for approximately an hour with hydrochloric acid (3N), preferably in a tube with a sintered bottom. The acid should then be slowly drained and fresh acid added.

When the level of the acid reaches the top of the bed, distilled water should be added from above, until the bed is rinsed free of excess acid. The exchangers can be regenerated to the desired form with strong solutions of the ion in question.

Most exchangers should not be allowed to dry, because, when rewetted, some types tend to break apart. If it is desired to have them in dry form, it is best to dry them in the salt form rather than in the hydrogen or hydroxide forms, as the latter are not stable at temperatures greater than 125°C. These acid and basic exchangers may be air dried and then placed over phosphorous pentoxide to remove the remaining moisture.

One should never pour dry exchangers into a tube and then add water from the top, because the tube will frequently break with explosive violence, owing to the swelling of some of the exchanger. It is better to drop the exchanger into water and then transfer it to a tube from a beaker.

Weakly dissociated exchangers tend to hydrolyze on rinsing with distilled water. Rinsing should be stopped as soon as the bed is free of excess electrolytes. Table 1 offers a guide to the conditioning of ion exchangers.

Operating Methods

Each problem in analysis will require its own procedures, but in general, ion exchangers, like other adsorbents, are placed in contact with the solution by either a static (batch) or a dynamic (column) method. In the static method, the exchanger is placed in contact with a given quantity of solution for a given period of agitation. The solution is then drawn off by decantation or filtration and analyzed for the desired constituents. This method has its limitations, as equilibrium con-

ditions must be considered. The adsorption of water from the solution by the dry exchanger may also be a factor.

The dynamic method, which consists of passing the water through a column of exchanger, is preferable, although the rate of flow should be determined. The resin can be kept in wet form. To compensate for the water in the exchanger, two alternative procedures may be followed:

1. The bed is rinsed with distilled water, and the water to be analyzed is passed through the bed. The initial portion (in an amount determined by experiment) of the effluent is discarded, and a quantity of the remainder is taken for analysis.

2. The bed is rinsed with distilled water. A given quantity of the water sample is passed through the bed and collected in a volumetric flask from the moment the water is in contact with the top of the bed. The water sample is followed with distilled water until the free ionic constituents are displaced from the bed. The volume is made up to the mark, so that the dilution factor is known.

Other Considerations

Before adopting an ion-exchange method for analytical procedures, it is necessary to decide whether to use an anion or cation exchanger, whether it should be strong or weak, what type of mobile ion should be employed, and whether static or dynamic conditions are preferable. Additional factors to be kept in mind are the size of the column, the flow rate, the temperature, the type and concentration of ions in the sample, and the presence of colloidal and suspended materials.

The selectivity of an exchanger for an ion depends on the size and valence of the ion, the type of active group in

the exchanger, the degree of cross linking of the resin matrix, and the ionic concentration of dilute solutions. The alkali metals are generally retained by the cation exchangers in the order: $\text{Cs}^+ > \text{Rb}^+ > \text{K}^+ > \text{Na}^+ > \text{Li}^+$. For the alkali earth cations, the order is: $\text{Ba}^{++} > \text{Sr}^{++} > \text{Ca}^{++} > \text{Mg}^{++}$. The transition metals show the series: $\text{Zn}^{++} > \text{Cu}^{++} > \text{Ni}^{++} > \text{Co}^{++} > \text{Fe}^{++}$. As between Fe^{+++} , Mg^{++} , and Na^+ , the order will favor the multivalent ions: $\text{Fe}^{+++} > \text{Mg}^{++} > \text{Na}^+$.

For weakly basic anion exchangers, the order is: $\text{OH}^- > \text{SO}_4^{--} > \text{CrCO}_3^{--}$

TABLE 2

Total Dissolved Ionic Solids in Boiler Water
(Chemical Analysis Versus
Cation Exchange*)

Sample No.	Total Solids—ppm (CaCO_3)		
	Chemical Analysis	Cation Exchange	Difference
1	2,712	2,798	+86
2	1,953	1,946	-7
3	1,831	1,832	+1
4	1,697	1,810	+113
5	1,428	1,446	+18
6	943	1,022	+79
7	651	682	+31
8	585	646	+61

* Based on unpublished results of E. K. Gilbert (Permutit Co.).

$> \text{NO}_3^- > \text{Cl}^-$. The OH^- is the weakest replacing ion in the strongly basic exchangers; otherwise, the same order holds for the remaining anions. These exchange series hold in dilute solutions but may vary at high ionic concentrations.

Boiler Water Analysis

Total dissolved solids. Robertson and Nielson (5) recommended the use of a sulfonic cation exchanger in the hydrogen form as a rapid test for determining dissolved solids in boiler

waters. A small portion of the exchanger (0.5 cu in.) was placed in contact for 30 sec with a cooled and filtered sample of water (25 ml) in a test tube. The free mineral acidity was determined on an aliquot with 0.02N sodium carbonate and methyl orange as the indicator. On another sample of filtered boiler water, the alkalinity was determined with 0.02N sulfuric acid. The free mineral acidity plus the alkalinity gave the total dissolved solids. Table 2 compares data obtained by actual analyses (Cl , SO_4 , alkalinity plus

TABLE 3

Total Dissolved Ionic Solids in Boiler Water
(Chemical Analysis Versus Chloride
Anion Exchange*)

Sample No.	Total Solids—ppm (CaCO_3)		
	Chemical Analysis	Anion† Exchange	Difference
1	2,504	2,300	-204
2	2,499	2,320	-179
3	1,997	2,104	+43
4	1,867	1,880	+13
5	1,826	1,740	-86
6	1,813	1,900	+87

* Based on unpublished results of M. A. Willich (Permutit Co.).

† A quaternary anion exchanger in the chloride form, Permutit S-2, was used.

one-third phosphates) and by the ion-exchange method on a number of boiler water samples.

M. E. Gilwood, of the author's firm, suggested the use of an anion exchanger in the chloride form for determining the total dissolved ionic solids in solution. A sample of the boiler water was passed through a bed of quaternary anion exchanger in the chloride form. The anions in the sample were exchanged for the chloride; and an aliquot was used to determine the total chloride concentration with a standard silver nitrate solution and

chromate as the indicator. Some results obtained with this method are given in Table 3.

Rivers and Marcy (6) used a highly basic anion exchanger in the hydroxide form. They mixed the exchanger with a sample of boiler water and, after shaking, titrated the hydroxide with a standard acid. An accuracy within 25-50 ppm was claimed. Some results with this type of exchanger, using the column method, are shown in Table 4.

Calmon (7) showed that the volume of a low cross-linked resin cation ex-

to absorb the calcium and magnesium, which were later eluted with a hydrochloric acid solution and then determined by chemical means. The excess phosphate was calculated from the difference of the hardness and the total phosphate in the solution.

Cooling-Water Analysis

Chromate ions interfere in many standard determinations of silica, phosphate, sulfate, metaphosphate, hardness, copper, and iron. Polyphosphates interfere in the hardness de-

TABLE 4

*Total Dissolved Ionic Solids in Boiler Water
(Chemical Analysis Versus Hydroxide
Anion Exchange*)*

Sample No.	Total Solids—ppm (CaCO ₃)		
	Chemical Analysis	Anion Exchange	Difference
1	833	816	-17
2	843	800	-43
3	958	964	+6
4	1,254	1,336	+82
5	1,380	1,512	+132
6	1,603	1,788	+185
7	1,808	1,668	-140
8	1,923	2,044	+121

* Based on unpublished results of Robert Irons (Permutit Co.).

changer of the sulfonated type depends on the ionic concentration of the solution in contact with it. A boiler water was passed through an exchange bed (10 ml in distilled water) until the minimum volume was obtained (approximately 100 ml of water was sufficient). The concentration was then read from a curve for the ion-exchange material standardized with a sodium chloride solution. The results obtained with the volume method are given in Table 5.

Excess Phosphates. Edelstein and Petatski (8) used a cation exchanger

TABLE 5

*Total Dissolved Ionic Solids in Boiler Water
(Chemical Analysis Versus Ion-
Exchange Volume Method)*

Sample No.	Total Solids—ppm (CaCO ₃)		
	Chemical Analysis	Volume Method*	Difference
1	2,900	2,798	-102
2	2,504	2,500	-4
3	2,499	2,500	+1
4	1,867	1,900	+33
5	1,850	1,830	-20
6	1,850	1,700	-150
7	1,826	1,800	-26
8	1,813	1,800	-13
9	1,100	1,108	+8

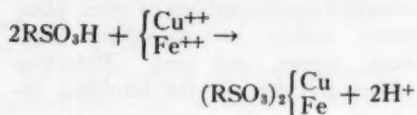
* A sulfonated cation-exchange resin, Permutit Q-1, was used.

termination by the compleximetric method. The examples below show how the interfering ion may be removed.

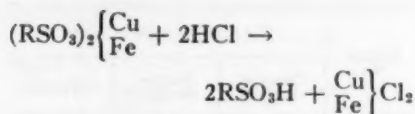
Determination of silica in presence of chromate. Sussman and Portnoy (9) passed cooling water containing chromate through a weakly basic anion exchanger in the chloride form. The chromate was exchanged for chloride. The silicate, which was not removed, was then determined by the usual colorimetric procedure. The method does not apply if fluoride is present. Also,

the initial three bed volumes of the effluent should be discarded.

Determination of heavy metals. The same investigators (9) determined iron and copper corrosion products in cooling water by passing the water through a bed of cation exchanger in the hydrogen form. The iron and copper were removed, while the chromate remained in solution:



The two ions were then recovered from the exchanger by eluting with hydrochloric acid:



The recovered cations were then analyzed by the standard heavy-metal tests. The test data of Sussman and Portnoy showed excellent agreement for iron concentrations from 0 to 13.5 ppm in solutions containing 500 ppm chromate and for copper concentrations from 0 to 4.2 ppm.

Determination of PO_3^- , PO_4^{--} , SiO_3^{--} and SO_4^{--} . To remove the interference of the chromate ion, McCoy (10) used hydroxylamine hydrochloride to reduce it to the chromic ion (a cation), which was then removed with a cation exchanger of the sulfonic acid type.

Determination of calcium and magnesium in presence of chromate and chromic ions. In this determination, McCoy (10) oxidized the chromic ions to chromate with alkaline peroxide and then passed the solution through a highly basic anion exchanger in the

chloride state. The effluent, free of chromate ions, was then titrated with an ethylenediaminetetraacetate solution for hardness determination.

Determination of calcium and magnesium in presence of copper and iron. McCoy (10) converted the copper and iron often present in cooling-water systems to the cyanide complexes with potassium cyanide. The cyanide complexes and excess cyanide were then removed with a highly basic anion exchanger in the chloride form, and the calcium and magnesium were determined in the effluent. If some cyanide is present in the effluent, the cyanide can be removed by boiling the slightly acidified solution for a few minutes before titration for hardness by the compleximetric method.

Determination of copper, iron, calcium, and magnesium in presence of chromate. McCoy (10) passed cooling water through a highly basic anion exchanger in the chloride form, to remove the chromate. The water sample was then split into two portions. One was employed directly for determining the iron and copper (the thioglycolic acid method was used for iron, and the sodium diethyldithiocarbamate method in ammoniacal citrate medium for copper). The second portion was passed through a fresh sample of anion exchanger after potassium cyanide had been added. With the iron, copper, and excess cyanide thus removed, the hardness determination was then carried out (10).

Determination of hardness in waters containing polyphosphates. Brooke and Holbrook (11) passed the water through an anion exchanger in the chloride form to remove the polyphosphate and pyrophosphates. The hardness was then determined on the second bed volume of effluent.

Natural-Water Analysis

Sulfate determination. Bahrdt (12), the first to apply ion exchangers to water analysis, removed the calcium and magnesium with a sodium cation exchanger, added a given quantity of barium chloride solution to precipitate the sulfate, and then determined the excess barium by the Blacher soap method. Hunt (13) determined the excess barium with ethylenediamine-tetraacetic acid. His results by this method averaged better than 99 per cent agreement with those obtained by the gravimetric method.

Fluoride determination. Shimizu (14) applied a sulfonic cation exchanger to remove cations interfering with the determination of fluoride by the aluminum hematoxylin method.

Total-hardness determination. Lure and Stefanovich (15) concentrated calcium and magnesium on a cation exchanger and then recovered the two with hydrochloric acid. Nydahl (16) extended this method to achieve the concentration of sodium, potassium, and manganese as well. Calmon (7) used a low cross-linked resin in the sodium form. The volume reduction in the cation exchanger on passing a given quantity of water through the resin bed was an indication of the hardness in the sample. Bergman (17) used both cation and anion exchangers to analyze permanent hardness in water, but the method given in his paper measured only the free mineral acidity product of the chloride and sulfate ions.

Total cation content. Blumer (18) determined the alkalinity of a water and the acidity formed on passing a sample of it through a hydrogen sulfonic acid exchanger. The sum of the two values gave the total cation content, as well as the anion content of

the water. Hoek (19) used the same method. Subtracting the total hardness from the total cation content, he designated the difference as the sodium and potassium content. Hilfinger (20) and others utilized cation exchangers for determining the total salt concentration by titrating the acidity formed on passing water through a cation exchanger in the hydrogen state. Kakihana (21) claimed the separation of the monovalent from the multivalent cations by first eluting the bed with a hydrochloric acid solution of low concentration.

Trace elements. Abrahamczik (22) concentrated trace quantities of copper, gold, iron, lead, radium, silver, and zinc. Similarly, Riches (23) used a cation exchanger to concentrate traces of cadmium, copper, manganese, nickel, and zinc. Elution was accomplished with strong hydrochloric acid solutions.

Oxygen determination. To determine dissolved oxygen in concentrations on the order of 0.01 ppm, Verbestel and colleagues (24) prepared oxygen-free water for reference samples by passing the water through an ion exchanger containing copper.

Other Applications

In many analytical procedures and studies, trace elements in distilled water must be removed. Liebig and others (25) removed traces of copper with cation exchangers. Radioactive contaminants may also be removed by ion exchangers (12).

Egner and colleagues (26) concentrated the ionic constituents of rain water with a hydrogen sulfonic cation exchanger and an alkali-regenerated anion exchanger. The ions were then recovered by passing acid and alkali solutions through the respective exchangers.

The review given here covers only analytical procedures applied to water analysis. Methods used for determining traces in other types of solutions may prove applicable to water analysis also.

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Sodium Determination With Ion-Exchange Resin

By Remo Navone

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Remo Navone, Div. of Labs., California Dept. of Public Health, Los Angeles.

THIS paper describes a procedure for using an ion-exchange resin to obtain a quick and fairly reliable estimate of the amount and percentage of sodium in a water, as well as to check the accuracy of chemical analyses. If a sufficient quantity of ion-exchange resin in the hydrogen form is mixed with a measured volume of natural water, the cations present in the water are exchanged for an equivalent amount of hydrogen ions derived from the resin. The alkalinity normally present in the water will neutralize some of the hydrogen ions produced, however, and must be taken into account. The entire procedure consists of three simple steps: [1] ion exchange, followed by titration with standard alkali; [2] alkalinity determination; and [3] hardness determination.

The apparatus required consists of a pH meter, line or battery operated; a magnetic stirrer, or any other with controlled speed; a 10-ml buret, graduated in 0.05-ml steps; and glass wool. The reagents comprise 0.02N sulfuric acid, 0.02N sodium hydroxide, a cation-exchange resin,* and distilled water.

Pipet 20.0–50.0 ml of the water sample into a 250-ml Erlenmeyer flask and add enough distilled water to bring the final volume to 100 ml. Add 2.0 g of

cation-exchange resin and stir the mixture at moderate speed for 15 min. Then filter it through a plug of glass wool placed in the neck of a 4-in. pyrex funnel. When the filtration is completed, wash the resin with two 15-ml portions of distilled water. Titrate the filtrate and washings to pH 4.5 with 0.02N sodium hydroxide, using a pH meter as endpoint indicator. Stir the solution during this titration.

The amount of alkalinity present in the raw water, in milliequivalents per liter, is determined by titrating an aliquot of water to a pH of 4.5 with 0.02N sulfuric acid, using a pH meter as endpoint indicator. The hardness in the raw water, in milliequivalents per liter, is determined from a separate aliquot, using disodium dihydrogen ethylenediaminetetraacetate.

The total milliequivalents per liter of cations present (D) can be found from the equation:

$$D = A \times 0.02 \times \frac{1,000}{B} + C \quad (1)$$

in which A is the volume (milliliters) of 0.02N sodium hydroxide used in titrating the filtrate from the ion exchange, B is the volume (milliliters) of raw water taken; and C is the alkalinity (milliequivalents per liter) present in the raw water.

For waters containing small concentrations of ammonium and potassium ions, Eq 2 can be used to estimate

* Amberlite IR-120(H), analytical grade, a product of Rohm & Haas Co., Philadelphia, was used.

TABLE 1
Sodium Determination

Sample No.	Sodium—mg/l		Sodium—per cent	
	Flame Photometer	Ion Exchange (Eq 2)	Chemical Analysis	Ion Exchange (Eq 3)
1	42	49	42	51
2	40	40	32	32
3	41	39	32	31
4	87	85	42	42
5	80	80	41	41
6	18	23	30	36
7	41	46	41	43
8	90	84	20	18
9	70	71	80	78
10	62	50	23	19
11	60	53	48	45

the sodium content:

$$23(D - H) = \text{mg/l Na} \dots (2)$$

in which H is the hardness (milliequivalents per liter). Equation 3 provides an estimate of the percentage of sodium in the raw water:

$$\frac{D - H}{D} \times 100 = \text{per cent Na} \dots (3)$$

Table 1 shows the results of applying Eq 2 and 3 to several water samples. The average deviation given by Eq 2 was ± 4.3 mg/l for the sodium estimation and ± 2.6 for the percentage sodium estimation.

When all the major ionic constituents of natural waters are quantitatively determined, the accuracy of the chemical analysis is checked by showing that the sum of the concentration of cations is equal to that of the anions. In many instances, however, the sodium content is obtained by difference; if this is done, a rapid method is needed to check the total ion concentration.

A standard solution was prepared, containing the following cations: magnesium, calcium, potassium, and sodium. Alkalinity was supplied by so-

TABLE 2
Total-Cation Determination

Sample No.	Total Cations—milliequivalents/liter		
	Chemical Analysis	Ion Exchange	Deviation
1	5.45	5.43	-0.02
2	5.60	5.51	-0.09
3	8.96	8.98	+0.02
4	8.58	8.57	-0.01
5	3.82	4.10	+0.28
6	2.58	2.79	+0.21
7	4.40	4.62	+0.22
8	20.06	19.78	-0.28
9	3.84	3.95	+0.11
10	12.02	11.51	-0.51
11	5.48	5.19	-0.29
12	8.82	8.77	-0.05
13	8.10	8.00	-0.10
14	0.65	0.63	-0.02
15	1.66	1.67	+0.01
16	2.18	2.18	0.00
17	0.44	0.45	+0.01

dium bicarbonate. This solution was treated according to the procedure outlined above. The results of three tests, as calculated from Eq 1, were 11.62, 11.81, and 11.67 milliequivalents per liter, while the theoretical total was 11.73. Table 2 indicates the degree of agreement between total milliequivalents per liter of cations as chemically determined and as found by the ion-exchange method. Experience has shown that the expected average deviation is approximately ± 0.12 milliequivalents per liter. The ion-exchange method is thus a good check on the accuracy of a chemical analysis.

Acknowledgment

The author wishes to acknowledge the valuable assistance given to him by the members of the staff of the Sanitation Lab., State Dept. of Public Health, Berkeley, Calif., who checked this procedure and obtained some of the data presented in the tables.

Lauryl Sulfate Tryptose Broth as a Presumptive and Confirmatory Medium for Coliform Organisms

By Alice K. Bicknell, John Middleton, and Thomas Neblett

A contribution to the Journal by Alice K. Bicknell, Chairman, Bacteriology Div.; John Middleton, Graduate Student; and Thomas Neblett, Graduate Student; all of Biology Dept., Wayne Univ., Detroit.

THE effect of various surface tension depressants incorporated into a medium selective for the coliform group has been reported by Mallmann and Darby (1). These authors recommended the use of lauryl sulfate tryptose broth (LSTB) both as a presumptive test and as a confirmatory medium for routine testing of coliform organisms. Cowles (2) had previously shown that lauryl sulfate incorporated into lactose broth gave a medium selective for coliform organisms. In spite of the work of these and other investigators and the apparent validity of the published data, there has been no general acceptance of the indicated medium by water works operators.

It has been possible, over a period of 3 years, for all water samples submitted to the authors' laboratory to be run on standard lactose broth and LSTB. In addition, comparable data have been obtained on wetting agents other than lauryl sulfate. An attempt has been made to further the work of Mallmann and Darby by verifying their results and also by showing that a special confirmatory medium is not necessary when lauryl sulfate tryptose broth is used as the presumptive medium.

Methods and Procedure

Standard lactose and lauryl sulfate tryptose broths were used as control media for all tests under discussion. To standard lactose broth and tryptose broth certain surface active agents have been added to ascertain the general effect of these on gas production by coliform organisms. Water samples were run with five tubes of each of three dilutions of the original inoculum. All of the waters employed were raw and untreated. They included samples from three small inland lakes—Kent, Orchard, and Cass—used largely for recreational purposes, and from potential sources for human consumption. In addition, a large number of private wells was sampled.

Incubation was at 35°C, and observations were made after periods of 6, 12, 18, and 24 hr. The presence of gas in any dilution of the control medium (lactose broth) was confirmed by standard procedures. Mallmann and Darby indicate that confirmations from LSTB may not be made with either brilliant green lactose broth or EMB agar.

To check the value of LSTB as a confirmatory medium, the following

protocol was adopted for tubes showing gas:

1. Direct microscopic examination
2. Indole test made directly
3. Methyl red test made directly
4. Acetoin (acetylmethylcarbinol) test made directly
5. Transferring of 0.5 ml to a tube of semisolid Simmons citrate medium and incubation in a water bath at 35°C; the tube is 45 × 5 mm and contains approximately 1.5 ml of medium; rapid results are assured (3).

There seems to be no reason to accept or reject a wetting agent, as far as incorporation into bacteriological media is concerned, on the basis of its surface tension; the surface tension of the commonly used wetting agents is approximately the same. Likewise, the toxicity effect at low concentrations is probably negligible. It is an accepted fact that many detergents may even act as growth factors in exceedingly small concentrations, although a higher concentration may prove to be toxic.

TABLE 1
Effect of Mentor Beads on Gas Production by Coliform Organisms*

Broth	Mentor Concentration per cent	Gas Production—ml			
		6 hr	12 hr	18 hr	24 hr
Lactose	1.0	0	0	to 1.0	to 1.0
	0.01	0	0	to 1.0	to 1.0
Tryptose	1.0	0	0	to 1.0	1-2
	0.01	0	0	1-2	1-2
Control					
Lactose	0.0	0	0	to 1.0	to 1.0
LSTB	0.0	0	0	1-2	1-2

* An anionic surface-active agent supplied by Colgate-Palmolive-Peet Co., Jersey City, N.J.

Results and Discussion

Data on the effect of adding two anionic surface-active agents to lactose and tryptose broths are presented in Tables 1 and 2. It is apparent that "Mentor" beads had no effect on gas production and that "Santomerse" acted in an inhibitory fashion. The effect of adding two nonionic surface-active agents is indicated in Tables 3 and 4. Although the "Sterox" compounds may be demonstrated to have some slight effect on gas production by coliform organisms, it is apparent that there is no logical reason for the substitution of one of these for lauryl sulfate.

It does not seem pertinent to attempt to explain the mode of action of lauryl sulfate and its selectivity for coliform organisms on the basis of the characteristics of the wetting agent itself. Rather, it may be postulated that the selective action shown is a resultant of the chemical differences of Gram-negative and Gram-positive bacteria. Gram-negative organisms contain at their surface a phospholipide of the cephalin type, which would negate or otherwise stop the bactericidal or bacteriostatic effect of the wetting agent on Gram-negative organisms but would have a positive or suppressing effect on Gram-positive bacteria.

Having established that LSTB is a selective medium for coliform organisms, it was questioned whether a confirmatory medium was necessary. The protocol previously indicated was adopted for confirmation from tubes showing gas in LSTB.

Direct microscopic examination showed the presence of Gram-negative, nonspore-forming rods. Gram-positive rods were not demonstrable.

The IMViC * tests were run directly from LSTB. The contents of a tube showing gas were divided into three

culture of *Esch. coli* (typing ++--), *Aer. aerogenes* (typing --++), and *Esch. freundii* (typing +--+). These were tested directly and by transfer to the appropriate medium—that is, tryptone broth, methyl red-Voges-Proskauer medium, and Simmons citrate.

The results show that, without question, confirmation of coliform organisms can be made directly from tubes of LSTB which show gas. In all tests to date, only one discrepancy was found, involving an indole test that

TABLE 2
Effect of Santomerse on Gas Production by Coliform Organisms*

Broth	Santomerse Concentration per cent	Gas Production—ml			
		6 hr	12 hr	18 hr	24 hr
Lactose	1.0	0	0	0	0
	0.01	0	0	0	0
Tryptose	1.0	0	0	0	0
	0.01	0	0	0	0
Control					
Lactose	0.0	0	0	to 1.0	1-2
LSTB	0.0	0	0	to 1.0	2+

* An anionic surface-active agent supplied by Monsanto Chemical Co., St. Louis, Mo.

equal portions; citrate medium was inoculated as previously described. Kovac's reagent for indole, Barritt's reagent for acetoin, and methyl red indicator were the conventional test reagents. Direct controls were established in two ways: The contents of a tube of LSTB showing gas were inoculated in tryptone broth and methyl red-Voges-Proskauer medium. These were tested, after appropriate incubation, by the reagents indicated. A second set of controls was established by inoculating LSTB with 0.1 ml of a 24-hr

showed positive in LSTB and negative in tryptone broth.

The authors are aware that Levine (5) has recommended that the Voges-Proskauer reaction be used only to indicate the formation of acetoin from glucose. There is increasing evidence, however, that coliform organisms and others which ferment lactose possess the enzyme, lactase, which would convert lactose to glucose and galactose. The authors have experienced no difficulty in demonstrating the presence of acetoin from LSTB by organisms which showed the same reaction, when grown in methyl red-Voges-Proskauer

* This classification is described in *Standard Methods* (4, p. 229).

TABLE 3
Effect of Sterox* on Gas Production by Coliform Organisms

Sterox Type	Broth	Sterox Concentration per cent	Gas Production—ml				
			6 hr	12 hr	18 hr	24 hr	48 hr
C-D	Lactose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	0	2+
	Tryptose	1.0	0	0	0	to 1.0	1-2
		0.01	0	0	to 1.0	1-2	
SK	Lactose	1.0	0	0	0	to 1.0	1-2
		0.01	0	0	0	to .10	
	Tryptose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	0	2+
6	Lactose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	0	2+
	Tryptose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	to 1.0	1-2
SE	Lactose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	0	2+
	Tryptose	1.0	0	0	0	0	to 1.0
		0.01	0	0	0	to 1.0	2+
Control	Lactose	0.0	0	0	0	to 1.0	to 1.0
	LSTB	0.0	0	0	to 1.0	1-2	2+

* A group of nonionic surface-active agents supplied by Monsanto Chemical Co., St. Louis, Mo.

TABLE 4
Effect of Triton* on Gas Production by Coliform Organisms

Triton Type	Broth	Triton Concentration per cent	Gas Production—ml			
			6 hr	12 hr	18 hr	24 hr
X-100	Lactose	1.0	0	0	0	
		0.01	0	0	0	
	Tryptose	1.0	0	1-2		
		0.01	0	0		
X-155	Lactose	1.0	0	0	0	
		0.01	0	0	0	
	Tryptose	1.0	to 1.0	1-2		
		0.01	2+	2+		
Control	Lactose	0.0	0	0	to 1.0	1-2
	LSTB	0.0	0	0	1-2	2+

* Nonionic surface-active agents supplied by Rohm & Haas Co., Philadelphia.

medium and tested with the suitable reagent.

It is believed that a confirmatory medium for use with LSTB is not necessary and that interpretation may be accurately made from the presumptive test.

Conclusion

Lauryl sulfate tryptose broth may be used as a presumptive and confirmatory medium for the detection of coliform organisms. The presence of indole, methyl red acidity, and acetoin may be investigated directly by appropriate reagents. If desired, inoculations may be made from LSTB to a

semisolid Simmons citrate medium to test this reaction.

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Customer Accounting at Sheboygan

By J. Allan Hammes

A paper presented on Sep. 24, 1953, at the Wisconsin Section Meeting, Milwaukee, Wis., by J. Allan Hammes, Asst. Secy. & Office Mgr., Board of Water Commissioners, Sheboygan, Wis.

INCREASED efficiency in the operation of a water utility can be achieved by improving office procedures as well as engineering and mechanical functions. Proper records not only assure correct charges for water consumption but also make it possible to provide complete accounting data to public service commissions and others requiring such information.

An outstanding feature of the Sheboygan, Wis., accounting system is the customer-numbering plan. All parcels of land in the city, whether occupied or vacant, have been assigned serial numbers. As annexations of surrounding territory are made, the numbering system is extended accordingly. A meter route map is kept, consisting of sketches of all lots and blocks in the city with their serial numbers. These are assigned in meter route order and anticipated customer sequence.

In 1931, when there were approximately 8,000 customers, 60 per cent of whom were metered, the Wisconsin Public Service Commission ordered the city to adopt universal metering. In consequence, a change in the method of billing was deemed advisable. After comparing four types of billing machines and systems, Sheboygan selected a method of customer accounting known as the "third-stub plan."

Before the new billing equipment could be put into operation, it was

necessary to design a new form of water bill and a summary sheet. Samples of these forms were obtained from the machine manufacturer and from a neighboring utility in which the proposed system was in use. Instructions in machine operation and billing were given to office personnel by manufacturer's representatives. Of the five office employees, two devote full time and two part of their time to customer billing, collecting, and accounting.

Meter Reading

The meter division consists of four employees, each of whom reads 90-120 meters daily during a 10-day period every month. The rest of their time is spent in removing, testing, repairing, and resetting meters and hand-delivering water bills promptly on the first of the month. Complaints of non-delivery of bills are very rare. Of the 11,200 meters now in service, 11,044 residential meters are read and billed quarterly and 156 meters for 109 industrial or commercial customers are read and billed monthly. The city is divided into three billing districts, with approximately 3,700 customers in each. One district is billed each month. There are nine accounts-receivable controls for the entire city, three per district.

Meter reading sheets (Fig. 1) are prepared for a 4-year period. The

meter readers' calculations are rechecked in the office. Although only one or two errors are found in a book of 200 sheets, the recheck assures smooth functioning of the billing machine. If the mechanical subtraction of the meter readings punched on the

an estimated bill, based on a 2-year average for equivalent quarters, is rendered. It is the policy not to estimate bills for two quarters in succession; instead, arrangements are made with the customer by telephone or letter to obtain an actual reading.

The meter reader takes note of any indication of leakage in the service line

**BOARD OF WATER COMMISSIONERS
SHEBOYGAN, WISCONSIN
METER READING - WATER DEPT.**

D. S. 2222-
Rev. 10-4

MONTH	DATE	READING	CONSUMPTION	DATE	READING	CONSUMPTION
FEB.						
JAN.						
DEC.						
NOV.						
OCT.						
SEP.						
AUG.						
JULY						
JUNE						
MAY						
APR.						
MAR.						
FEB.						
JAN.						
DEC.						
NOV.						
OCT.						
SEP.						
AUG.						
JULY						
JUNE						
MAY						
APR.						
MAR.						
FEB.						

DISTRICT NO. 3

SIZE _____ RING _____ MFD. NO. _____ DATE SET _____
 SIZE _____ RING _____ MFD. NO. _____ DATE SET _____

MIN. _____

Fig. 1. Meter Reading Sheet

The meter reader's calculations are rechecked by machine to insure accuracy.

keyboard does not agree with the book, the machine will lock, thus slowing up the billing operation.

When a meter is out of service—approximately 90 a year require ordinary repairs—or no reading is possible,

**CITY WATER DEPARTMENT
SHEBOYGAN, WISCONSIN
Customers' Premises Report**

No 4200

Date _____ Hour _____

Name _____

Address _____

We wish to inform you that on the date shown:

- (1) Your curb stop was found out of order. page 9 ☐
per. 1
- (2) Your basement stop and waste was found out of order. page 9 ☐
per. 2
- (3) Inspection shows service leak on premises. page 9 ☐
per. 3
- (4) No back valves on meter. page 9 ☐
per. 4
- (5) Your meter is not accessible to reader. page 9 ☐
per. 5
- (6) Water service will be shut off from _____
to _____ to repair main. page 2 ☐
page 4
- (7) Water meter damaged by frost. page 10 ☐
per. 6
- (8) Water meter damaged by hot water. page 10 ☐
per. 7
- (9) Higher than normal meter reading indicates possible leak in house piping or fixtures.
- (10) _____

Inspector _____

(See rules on reverse side)

Fig. 2. Customers' Premises Report

This notice is left with the customer whenever the meter reader notes a leak or other defect.

or fixtures, and a "customers' premises report" (Fig. 2) is left at the door. If the occupant is not the owner, a copy is mailed to the latter as soon as the meter book is returned to the office. Such prompt notification of an abnormal reading enables the property owner to prevent the water wastage

that would otherwise occur during the several weeks between reading and billing. This practice builds customer goodwill by reducing complaints of high bills.

If the reader cannot gain access to the meter, he does not make a repeat call but leaves a self-addressed post-

cards, 85 per cent are returned with the reading, 98 per cent of them correct. This plan greatly reduces the number of estimated bills.

Billing

Another feature of the customer-accounting system is the use of a color



Fig. 3. Electric Billing Machine

Water bills are made out directly from the meter reading sheets. The printed bill is automatically ejected from the carriage.

card showing a diagram of the meter dial and instructing the customer how to fill it in. Approximately 250 such cards are distributed on the 3,700 meter reading calls each month. Of these

code for water bills, meter reading sheets, and summary sheets. The colors for quarterly accounts in the three districts are pink, yellow, and blue, while green is used for the

monthly accounts. As the districts are billed in rotation, the attention of the window clerk is instantly attracted to a tardy bill, for which a 5 per cent penalty is assessed. The color code eliminates the eyestrain necessary to identify noncurrent bills by serial number or date.

The water bill shows a breakdown of consumption by steps, so that, using the rate schedule printed on the back, the customer can easily check the computation. The addressograph plates or stencils are arranged in the same numerical sequence as the meter reading sheets. After the electrically operated

upon completion of computation and is stacked on a bracket.

After the billing operation has been completed and the computations have been checked, the "third stubs" are separated from the bills and placed in the unpaid accounts-receivable files in serial-number order.

Collecting and Accounting

All collections are handled by the water department, payments being received in the utility's office. An electric perforator receipts the bill and cuts off the cashier stub in the same opera-

SUMMARY OF BILLS					SHEBOYGAN WATER DEPARTMENT					
READING DATES		METER READINGS		CONSUMPTION	STEPS				PENALTY	NET
PRESENT	PREV	PRESENT	PREV		1ST	2ND	3RD	4TH & 1TH		

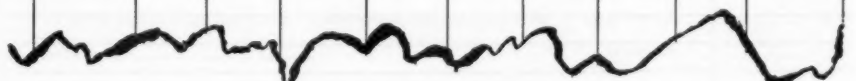


Fig. 4. Summary Sheet

This form provides a carbon copy of every bill printed on the machine.

automatic-feeder addressograph has stenciled the name of the customer, house number, delivery instructions (if any), date of bill, and final discount date, the forms are ready for the biller, who has the meter reading sheets and rate charts conveniently placed.

The billing machine (Fig. 3) is electrically operated. The forms are fed singly, by hand, into the carriage of the machine and held mechanically in place over a summary sheet (Fig. 4), on which a carbon copy of each water bill will appear. The printed bill is automatically ejected from the carriage

tion. Automatic change machines are in use to speed change making. Less than 10 per cent of the payments are made by mail.

At the end of the day, the cashier stubs are sorted into serial number sequence, added, and balanced with the cash taken in. Money received is deposited daily in the bank, and the bank receipt is turned over daily to the city treasurer, together with a duplicate set of collection report sheets. The treasurer keeps a separate cash book on water works funds. The collection sheet establishes a control between

source of the water used in constructing the building (such use of water is billed at flat rates).

The utility makes all taps in water mains. A plumber lays in the customer's service from the main at the owner's expense, and it is maintained by the owner. The entire cost of street mains is borne by the utility. All meters are owned by the utility and are issued free to the plumbers, who make the original installation at the

utility, but, if the damage is caused by frost, hot water, or some other type of negligence on the part of the owner, the cost of the repair is charged to him. The utility has, however, adopted a practice of making a free repair for the first instance of meter damage by frost or hot water. Meters are removed, tested, and, if necessary, reconditioned by the utility once every 7 years. Records (Fig. 6) of routine tests are kept on file for future reference.

ADDRESS _____		FOLIO NO. _____
SIZE _____	MAKE _____	METER NO. _____
DATE REMOVED _____		READING _____
REASON FOR REMOVAL _____		
TEST AT TIME OF REMOVAL:		
15 GPM _____%	1 GPM _____%	1/4 GPM _____%
REPAIRED _____	CLEANED _____	TESTED _____
TEST AT TIME OF RESET:		
15 GPM _____%	1 GPM _____%	1/4 GPM _____%
DATE RESET _____		READING _____
REMARKS _____		

JOB NO. _____		WORKMAN _____

Fig. 6. Meter Test and Repair Record

Meters are tested routinely once every 7 years. The cards are filed for future reference.

property owner's expense. If there is more than one service in a building, each unit is entitled to a free meter.

When a meter is issued to a plumber, a meter installation inspection followup card is made out, so that the inspector can check to see that the work is done properly and promptly. All meter repairing is handled by the utility. When damage is due to ordinary wear, the cost of the repair is absorbed by the

Upon completion of an installation, a "customers' premises data card" is made out, as well as an addressograph stencil plate and a meter reading sheet. The system of followup inspections makes it almost certain that no new customer will be missed. The building inspector's office submits a weekly list of construction permits, from which the utility learns of prospective customers.

Should any omission occur, it would be picked up by the meter reader on his next round, because, with universal metering in effect, he would expect to have a reading sheet for every occupied place. Thus, an unmetered or unrecorded account would never be more than 3 months old before it was discovered.

Delinquent Accounts

For health and sanitary reasons, the city council has ordered that water is never to be turned off for nonpayment of bills. Arrears are carried forward until the end of the fiscal year. A notice mailed to the owner fixes a deadline for payment before the debt is transferred to the city comptroller for special assessment against the property involved.

In 1952 the utility sent out 962 such notices to delinquents, of whom 628, or 65 per cent, paid by the deadline date. The remaining 334, representing 3 per cent of all accounts, were transferred for collection by the city treasurer. The amount involved was \$4,672.24, or 1.75 per cent of the gross revenue from water customers. The city treasurer forwards a check to the utility for the full total after the January and February tax collections. Thus, the utility collects every cent of water revenue billed.

Customer accounting accomplished by machine billing insures accurate calculations, permits flexibility in routine and uniform handling of daily work, largely eliminates duplication of effort, and affords neat, accessible records of all financial and statistical data required.



Effects of Lime Softening

By Merrill L. Riehl, Herbert O. Hartung, and Frank S. Taylor

A paper originally presented as a panel discussion on May 12, 1953, at the Annual Conference, Grand Rapids, Mich., by Merrill L. Riehl, Supt. of Water Purif., Mahoning Valley San. Dist., Youngstown, Ohio; Herbert O. Hartung, Supt. of Production, St. Louis County Water Co., University City, Mo.; and Frank S. Taylor, Asst. Supt.-Engr., Water Dept., Oklahoma City, Okla.

LIME has been employed as a chemical agent in water treatment for many years. Originally it was employed in water softening only, but, as the use of the material became more widespread, other desirable effects were noted. The application of larger dosages of lime resulted, eventually developing into the so-called excess-lime treatment.

By adding lime in sufficient amounts to produce a pH value of 10.5-11.0 or even slightly higher, several benefits are obtained: an increased amount of magnesium is removed from the water; clarification is improved, usually with less coagulant; and—quite important—there is a pronounced bactericidal effect. On the other hand, there have been some observations of chemical attack on nonferrous metal by the water at high pH levels. This paper will deal with the relation of lime-softened water to bacteriological quality, main disinfection, and zinc-bearing metals.

Bacteriological Quality

The beneficial effect of lime treatment on the bacteriological quality of water was noted by Houston (1) at London, England, in 1912. In the United States, most of the credit for the early observations (2-5) of this ef-

fect must be attributed to the late Charles P. Hoover, who was the guiding genius of the Columbus, Ohio, water purification plant for more than 40 years. Ironton, Cincinnati, and Youngstown, Ohio, verified Hoover's findings and took advantage of the disinfecting action of lime. Still further evidence was presented in reports by H. W. Streeter (6, 7) on the observations made at the US Public Health Service laboratories in Cincinnati.

During World War II the need for further research on the bactericidal action of lime was brought out. Some Ohio cities that supplied water to Army installations were unwilling to depart from their then satisfactory treatment solely to satisfy the Army stipulation of 0.4 ppm chlorine residual in all active parts of the distribution system. Controversy on this subject was brought to the attention of the Ohio Dept. of Health. On the strength of the available evidence, the Army authorities decided, quite reluctantly, to accept the water from these cities.

One result of this controversy was the inauguration of specific research projects on lime as a sterilizing agent. The first of these was carried out under the supervision of H. W. Streeter and was reported by Wattie

and Chambers (8) in 1943. A second project was undertaken a few years later at the Ohio Dept. of Health laboratories on the Ohio State University campus. The work was financed by funds from the National Institutes of Health and was under the joint supervision of H. H. Weiser of the Ohio State University Dept. of Bacteriology and Merrill Riehl, who at that time was with the Ohio Dept. of Health laboratories. A summary of the findings of this project was reported (9) in 1952.

The conclusions indicated by these studies are that, at a pH level of 11.0-11.5 and a contact time of 4 hr, removal of the test organism is on the order of 100 per cent. The composition of the raw water does not have an appreciable influence on the survival of the organisms.

Mahoning Valley Sanitary Dist.

Experience at the Mahoning Valley Sanitary Dist., Ohio, confirms the bactericidal effect of lime-treated water. With a pH value in the range of 10.6-10.9, the coliform index of the settled water averages approximately 1 per cent of that of the raw water; this reduction is accomplished in an average detention time of $3\frac{1}{2}$ hr. After filtration and before chlorination, the index is still lower, usually less than 0.1 per cent of that of the raw water. With a longer contact time and higher pH values, the percentage reduction is even greater.

Although the bacterial load in the raw water usually is rather low, completely satisfactory treatment is achieved even during periods of high counts. Some variations in plant operation are, however, frequently required in order to accomplish the treatment most effectively.

Eastern Ohio Village

Another example of the value of lime in solving difficult treatment problems is provided by a small village in eastern Ohio which was experiencing difficulty in producing a safe and palatable water from a surface supply of unsatisfactory quality. The use of soda ash, alum, chlorine, and ammonia failed to yield a satisfactory water, and the conditions in the mains and the elevated storage reservoir made free residual chlorination unadvisable. In order to produce a water that the consumer would drink, the bacteriological quality had to be allowed to hover dangerously close to the unacceptable level. A further difficulty arose when an unusual set of circumstances introduced phenols into the water supply in such concentrations that a 50-ppm dose of activated carbon was needed for several weeks in order to make the water palatable after chlorination.

The local superintendent finally adopted the use of excess lime. This treatment permitted the discontinuance of soda ash, a 75 per cent reduction in the application of chlorine and ammonia, and a 50 per cent reduction in alum feed. More important, however, was the complete elimination of all gas-forming organisms in the finished water. The superintendent now reports compliments, instead of complaints, on the taste of the water for the first time in his memory. If the phenol problem should arise again, it is planned to discontinue chlorination temporarily and rely on excess lime alone to produce a bacteriologically safe water.

St. Louis County Water Co.

Lime softening of Missouri River water, as practiced at the St. Louis County Water Co. treatment plant, re-

sults in an appreciable bacterial reduction. Such softening does not, however, produce a bacteriologically safe water.

The raw water at the treatment plant has an average coliform index of 20,000 per 100 ml and an average 37°C agar count of 33,000 per milliliter. The lime dosage is adequate to react with all the alkalinity and to produce a caustic alkalinity of 2-3 ppm to enhance coagulation. This treatment raises the pH of the raw river water from about 8.0 to 10.2. After an average basin detention of 3 hr, the high

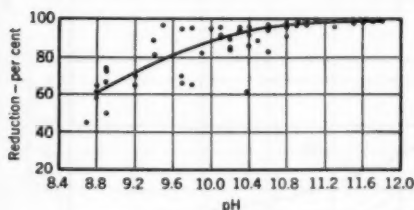


Fig. 1. Effect of Lime Treatment on Total Bacterial Count

The percentage reduction in total count (37°C agar) is plotted against pH after lime treatment. The average count of samples shown was 5,000 per milliliter.

pH alone reduces the coliform count an average (10 years) of 83.5 per cent and the 37°C agar count 93 per cent. Although these reductions are significant, the water remains unsafe.

In laboratory tests on Missouri River water, it was determined that a bacteriologically safe water was obtainable with lime treatment when the pH was raised to 11.4 or more. The caustic condition of such water, however, makes it unfit for domestic use.

The laboratory tests were made with various amounts of lime, mixed for 60 min and then settled for 60 min. The

temperature of the test samples was kept the same as that of the river water by means of a water bath. Samples were collected prior to and at the end of each experiment and were tested for total count and coliform indexes. Some results of these tests are shown graphically in Fig. 1. It will be noted that, when the pH of the water was 11.2 or more, the total-count reduction approached, but did not quite reach, 100 per cent. For coliform organisms, the results were quite similar, except that, at a pH of 11.4 or higher, coliform organisms were completely eliminated. Below that pH, no dependence could be placed on the complete removal of coliform bacteria.

A typical lime-softening study on Missouri River water (Fig. 2) shows that twice as much lime is required to produce pH 11.4 as to obtain maximum softening at pH 10.3. A further inspection of the curves will show that, at pH 11.4, the hardness was increased from 159 to 190 ppm. Similarly, at pH 11.4, although the magnesium is completely removed, the calcium has increased from 110 to 190 ppm expressed as calcium carbonate. Maximum bacterial reduction parallels maximum magnesium and turbidity precipitation. At pH 11.4, the turbidity was reduced from 1,400 to 8 ppm. This observation suggests the possibility that at least some of the bacterial reduction obtained during lime softening is the direct result of precipitation and sedimentation.

Although lime softening is responsible for an appreciable bacterial reduction, it also adversely affects chlorine disinfection. The amount of chlorine required to obtain complete reduction of the 37°C agar count on a sample of Missouri River water was determined in the laboratory. Approximately 3.5

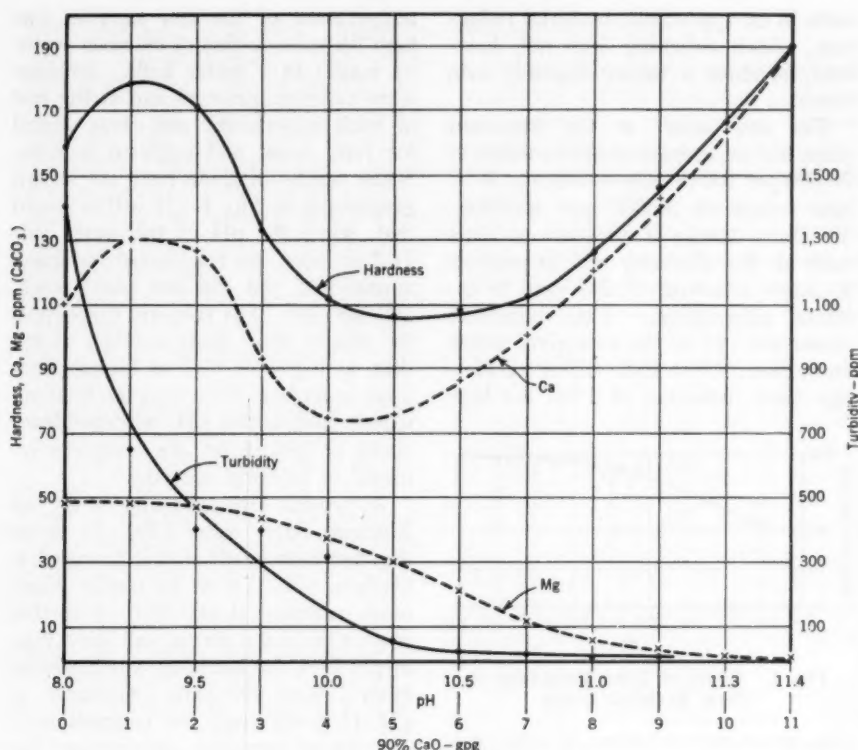


Fig. 2. Turbidity and Hardness

The fact that turbidity reduction parallels bacterial reduction (Fig. 1) suggests the possibility that at least part of the bacterial decrease is due to precipitation and sedimentation. (Lime doses are expressed in grains per gallon; pH is after treatment.)

ppm chlorine was required for complete bacterial kill at pH 8.0, while approximately 9 ppm was needed at pH 10.5. At pH 11.0 or more, the chlorine dosage required for 100 per cent kill was ridiculously high.*

The effect of pH on the chlorination of Missouri River water is further illustrated in Fig. 3, which shows typical "breakpoint" curves and 37°C agar

count reductions. At pH 8.3, the chlorine residual-chlorine applied curve shows a typical "break" at 3.5 ppm applied chlorine. At pH 10.4, chlorine residuals are higher, but the typical break in the chlorine curve has almost been lost. The bacterial reductions at pH 8.3 are appreciably greater than at pH 10.4, when the applied chlorine is higher than 3.5 ppm. When less chlorine is applied, bacterial kills are influenced more by the pH of the water than by the amount of the chlorine dosage.

* Reference to the adverse effect of high pH on the disinfecting action of chlorine may be found in the *Manual of Water Quality and Treatment* (10).

These experiences and tests at the St. Louis County Water Co. plant indicate that there is little reason for the simultaneous disinfection of water with lime and chlorine.

Main Disinfection

The effect of lime-treated water on main disinfection is illustrated by the practice at Youngstown and Niles, Ohio, where the high pH and low residual chlorine content of the water is

the owner had moved, but samples were procured immediately after notification. The odor of the water unmistakably indicated the presence of decayed animal matter, and, when the city maintenance men reluctantly dug up the new main at that location, they discovered the remains of a well decomposed rabbit. The situation cleared up very shortly thereafter. The point of this story is that water samples taken at this site were found to be bacteri-

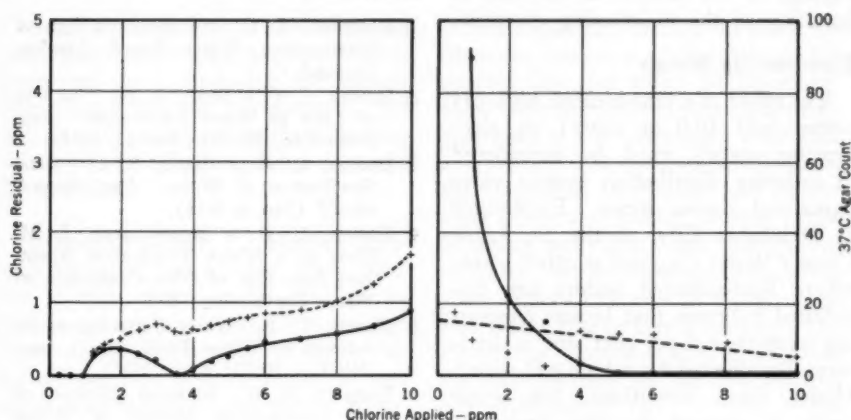


Fig. 3. Lime Treatment and Chlorination

In both graphs, the broken line applies to chlorinated raw water (pH 8.3) and the solid line to chlorinated, lime-softened water (pH 10.4).

relied on to destroy all bacteria in new mains. The results obtained have been satisfactory.

To cite another example, the water department of one of the member cities of the Mahoning Valley Sanitary Dist. encountered an odor problem that the local people could not solve. A homeowner was forced to move out of his new house, which was isolated in a remote part of a new subdivision, because of the unpalatable water. The district was not informed of this problem until

ologically safe, even when the odor was at its worst.

Lime disinfection of distribution mains has been successfully employed at Oklahoma City, Okla. The method is based on experimentally determined applications of lime sufficient to produce a pH of 12.4 in the water in contact with the mains to be disinfected. It is reported that samples of water from the treated and flushed mains have been presumptive negative after a 48-hr incubation. (All jute for pack-

ing bell-and-spigot leaded joints is also disinfected with lime before use.)

The success of this method of main disinfection depends upon a thorough wetting of the interior of the pipe with the caustic water. Care must be taken in the preparation of the lime slurry to obtain thorough mixing with the water during pipe-filling operations. Moreover, a comparatively clean pipeline would appear to be prerequisite to the application of this method. One advantage of the method is the ease of handling of the disinfecting chemical.

Zinc-bearing Metals

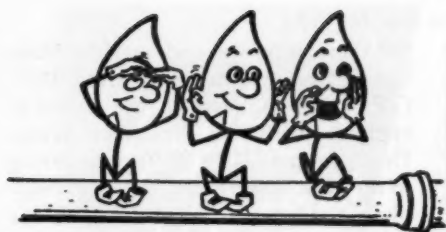
The effect of a lime-treated, high-pH water (pH 10.0 or more) on zinc-bearing metals must be considered in ordering distribution system valve parts and similar items. Experience at Oklahoma City, at the St. Louis County Water Co., and at other plants where lime-softened waters are distributed indicates that bronze containing more than 6 per cent zinc is detrimentally affected by a high-pH water. Under these conditions, the water tends to remove the zinc from the metal, resulting in structural weakness. Utilities with high-pH waters would be well advised to take this problem seriously, and thereby avoid valve failures.

The ASTM specifications for Grade I Bronze provides for a zinc content of only 4 per cent. This bronze (copper 84 per cent, tin 4, lead 4, zinc 4, and other metals 4) is well suited for use with a water having a high pH. In contrast, Grade II-IV bronzes have a zinc content ranging from 36 to 39 per cent and are unsuited for such service.

A word of caution is needed, however, with regard to Grade I bronze: Although it has the proper characteristics to prevent dezincification by high-pH waters, its low tensile strength, as well as certain other physical characteristics, is a disadvantage when it is used in valve stems. Silicon and aluminum bronzes, suggested by several manufacturers, may offer a solution to the problem.

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Percolation and Runoff

Seattle's welcome is now awaiting what promises to be the largest AWWA gathering ever. Just what will happen there you'll find out for yourself. All we can say now is that the following roster of new officers and directors will be installed:

President—Dale L. Maffitt, general manager, Des Moines, Iowa, Water Works. Born in Des Moines in 1892, and recipient of a B.S. degree from Drake University in 1914, he joined the Des Moines Water Works upon his graduation and served as assistant chemist. In 1916 he was made chief chemist, and in the course of the next ten years at this occupation he also found time to undertake graduate work in chemistry and chemical engineering at Massachusetts Inst. of Technology. The next steps up the ladder were his appointment in 1926 to be assistant to the general manager, and finally, in 1933, promotion to the post of general manager.

An AWWA member since 1918, Maffitt's extensive activities have made him chairman of the old Missouri Valley Section, and twice director for the Iowa Section, which gave him the Fuller Award in 1949. At the time of his election to the vice-presidency last year, in addition to serving as his

section's director, he answered to the titles of: chairman of the Water Resources Div. (of which he has previously been director and vice-chairman), chairman of the Committee on Public and Worker Relationships, chairman of the Committee on Pension and Retirement Plans, and, finally, member of the following committees and task groups—Water Works Administration, Program, Safety Practices in Distribution, and Water Use in Fire Prevention and Protection. Previous activities include the chairmanship of the old Finance and Accounting Div., of the Fuller Award Society, and of the Committee on Social Security Legislation; plus membership in committees on Water Works Practice, Survival and Retirement Experience With Water Works Facilities, and Federal Activities.

Vice-President—Frank C. Ambary Jr., vice-president and secretary, Illinois Water Service Co., Champaign, Ill. Born in 1900 and graduated from the University of Illinois with a C.E. degree in 1922, he is a registered professional engineer in Illinois. He joined the Champaign-Urbana Water Co., predecessor of his present firm, in 1923 as supervising engineer. He became manager in 1927, director in 1936, secretary in 1937, and vice-president in

(Continued on page 32 P&R)

(Continued from page 31 P&R)

**V. P.—Amsbary****Treasurer—Brush**

1939. He continues to hold these posts, and in addition is vice-president of the Northern Illinois Water Corp.

Amsbary joined AWWA in 1927, and has distinguished himself in a host of activities. He has been trustee, vice-chairman, chairman, and director of the Illinois Section, which gave him its Fuller Award in 1941. He has held the posts of secretary-treasurer, vice-chairman, and chairman of the AWWA Plant Management and Operation Div. and secretary of its successor, the Water Works Management Div. Committees of which he has been chairman include those on Water Use in Air Conditioning and Other Refrigeration, and Recommended Design for Valve Boxes and Covers. He has also served on the Committee on Water Works Administration, the Goodell Prize Committee; the Committee on Service Line Materials, and the Special Committee of 1941 on the Nicholas S. Hill Cup.

Other organizations in which he is active include ASCE; the National Society of Professional Engineers; the Public Utility Advisory Committee of the College of Commerce, University of Illinois; and two college engineering societies: Theta Tau and Musan.

Treasurer—William W. Brush, editor of *Water Works Engineering*. Brush was born in Orange, N.J., in

1874 and was educated at New York Univ., from which he received B.S., C.E., and M.S. degrees. He served as engineer with the Brooklyn Water Dept., from 1894 to 1907, transferring to the New York Board of Water Supply in the latter year. In 1910, he was shifted to the city's operating division, the Dept. of Water Supply, Gas, and Electricity, as deputy chief engineer of water supply. In 1927 he was appointed chief engineer of water supply, and served in that capacity until 1934, when he retired after a cumulative total with the three organizations of 40 years of service. He then began his present affiliation with the Case-Shepherd-Mann Publishing Corp. as editor of *Water Works Engineering*.

His reelection as treasurer continues an unbroken record of 32 years of high office in the Association, for, except for a two-year interval in 1928-29 when he was successively vice-president and president, Brush has been holding AWWA's purse-strings since 1922. In that time also he has been active on many committees, and has served ex officio as a member of both the Board of Directors and its Executive Committee. He received the John M. Diven Medal in 1932 and in 1937 was made an Honorary Member.

SECTION DIRECTORS

California—Burton S. Grant, chief engineer of water works and assistant manager, Dept. of Water and Power, Los Angeles. He was born in Herald, Ill., in 1904 and came West to attend the University of California at Los Angeles in 1924. The following year he joined the Dept. of Water and Power as a draftsman in the water system. A succession of engineering posts followed, and he was appointed to his present post in 1950.

(Continued on page 34 P&R)

*Compliments
not Complaints*
about the
taste of your
water!

● Water treated with AQUA NUCCHAR—activated carbon—is more agreeable to the senses of taste and smell. Moreover, the sparkling appearance—cut diamond effect—of such water has an enhanced aesthetic value both for the water plant operator and for the consumer. AQUA NUCCHAR, thus, helps provide water that is palatable to the taste and smell as well as pleasing to the sight.

Threshold Odor Technicians from INDUSTRIAL will be pleased to work with you, without obligation, to seek out the most economical means of employing AQUA NUCCHAR in your system. These Technicians, as part of their regular service, will assist you in the techniques of making the Threshold Odor Test. INDUSTRIAL will run an odor survey of your plant and determine the proper point for application of the carbon. Likewise, a check will be made on the influences of other chemicals used in your process to ascertain the most efficient point of AQUA NUCCHAR application.

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industrial
CHEMICAL SALES
division west virginia pulp and paper company

CITY OF WATERTOWN, NEW YORK
WATER DEPARTMENT
THOMAS B. FLORESLEY
Superintendent

January 25, 1954

Industrial Chemical Sales Division
West Virginia Pulp & Paper Company
230 Park Avenue
New York 17, New York

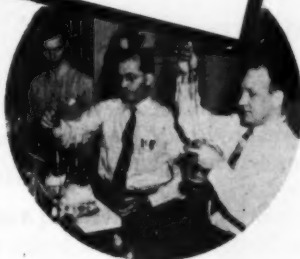
Attention: Mr. J. E. Drury
Gentlemen:

Please accept my thanks and appreciation for your recent immediate response to, and cooperation with our consultants, Malcolm Pirnie Engineers. The work done by Mr. Henry F. Laughlin, your Assistant Director of Research, and Mr. John Foster of Malcolm Pirnie Engineers in determining a treatment to eliminate the bad taste and odor present in our water last October and November gave immediate results.

The recommended treatment of 12 pounds of Aqua Nuchar in slurry form applied directly to the tops of the filters reduced the threshold odor from 10 to 5 with the result that we soon began to receive compliments on our water in place of the flood of complaints that had been customary.

The occurrence of bad taste in our water has been extremely erratic in the past and it may be some time before it develops again but I am sure that your Research Staff has given us a method of treatment that will successfully combat future trouble.

Sincerely yours
Thomas B. Floresley
Superintendent



Photograph: Mr. John Foster, Malcolm Pirnie Engrs. (left), and Mr. Henry F. Laughlin (center), INDUSTRIAL'S Assistant Director of Research, work with Mr. Dale Lawson (right), Watertown, N. Y., Water Department.

Photograph through courtesy of
WATERTOWN DAILY TIMES.

(Continued from page 32 P&R)



California—Grant



Chesapeake—Auld

A member of the American Geophysical Union and ASCE, he joined AWWA in 1934 and has served as California Section secretary-treasurer, chairman, and Executive Committee member. He is also serving on the AWWA Committee for Water Resources and the Water, Sewage, and Industrial Wastes Joint Committee on Critical Materials.

Chesapeake—David V. Auld, director of sanitary engineering, Dist. of Columbia. He was born in 1907, obtained the B.S.C.E. degree from Princeton University in 1929, and is a registered professional engineer in the Dist. of Columbia.

After working successively as a construction inspector, assistant design engineer, and senior engineer for the design and construction of sewers and sewage systems, he became assistant superintendent of the Dist. of Columbia Water Div. in 1942. Four years later he was advanced to the post of superintendent and chief engineer, and in 1953 he became director of sanitary engineering. He is also commissioner of the Interstate Commission on the Potomac River Basin.

A member of AWWA since 1944 and chairman of his section in 1951, he also belongs to ASCE, the Society of American Military Engineers, the Maryland-Delaware Water and Sew-

erage Assn., Princeton Engineering Assn., and the Washington Society of Engineers.

Cuban—Gustavo A. Bequer y Herrera, hydraulic and sanitary engineering consultant, Havana. A graduate of Havana University, from which he received degrees as a civil engineer in 1937 and as a specialized sanitary engineer in 1941, he has designed and supervised the construction of a number of water supply projects in Cuba. He has twice been a member of the Havana Forum fostered by the AWWA Cuban Section to discuss that city's water sources, and is a member of the Scientific Council of the Inst. of Medical Hydrology and Climatology. Other organizations to which he belongs are the School of Civil Engineers of Cuba, the Cuban Society of Engineers, and the American Public Health Assn.

Florida—Wylie W. Gillespie, consultant and partner, Smith and Gillespie, Jacksonville. He hails from Arlington, N.J., where he was born in 1906, and came to Florida as a partner in the firm of Lacey and Gillespie at Tavares in 1928. In 1932 he was made county surveyor for Lake County, with headquarters at Tavares, and engaged in private engineering practice at Orlando and Tavares until 1940, when he formed his present association.



Cuban—Bequer H.

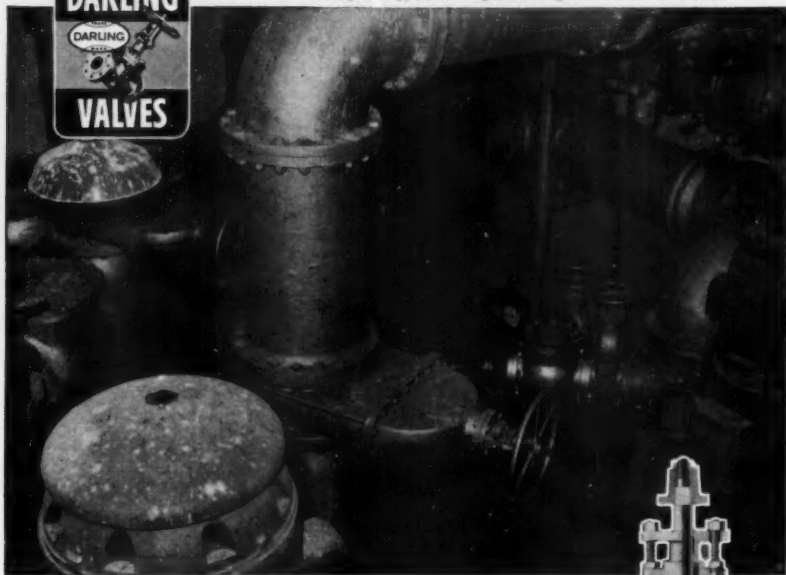


Florida—Gillespie

(Continued on page 38 P&R)



The Wet Well Pump Room in the central control building basement, showing Darling fully revolving double disc gate and check valves installed.



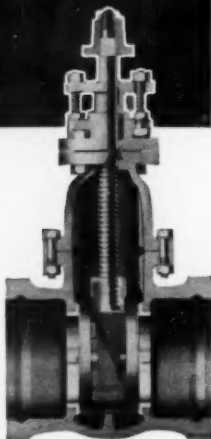
DARLING VALVES in Bethlehem's \$5,000,000 sewage treatment plant

THIS new Sewage Authority settling plant, with maximum capacity of 25,000,000 gallons a day, handles the sewage load from 128 miles of Bethlehem, Pa.'s sewer system.

Unique Valve Principle—Darling gate valves, in the "heart of the plant", are closer to being trouble-proof than any you have ever run across. Darling's fully revolving double disc, parallel seat feature compensates automatically for valve body distortion. Tight closure is assured every

time. In addition, wear on parts is less . . . and is uniformly distributed. Darlings last longer, require less attention and maintenance.

Valves For Every Need. In water and sewage plants everywhere Darling revolving double disc parallel seat gate valves are setting records for low-cost service. They are available in a wide range of sizes for all normal and unusual service . . . for pressures up to 1500 pounds. Write for all the facts to . . .



Rugged simplicity is the secret of better operation of the Darling revolving disc principle. Just four sturdy working parts . . . two plain interchangeable support discs and two hasty wedges . . . do all the work. With this foolproof assembly of internal parts, maintenance is easy.

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WATER

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BADGER meters conserve it!

More than 25 million acres of crops must be irrigated to provide America's food supply. The Badger water meters used in thousands of communities throughout the nation help save water for this vital need . . . measure water accurately for homes and industry . . . provide a precise check on water usage and waste. With their outstanding record of performance, Badger meters have won the praise of waterworks men everywhere . . . are known as the meters that save water, work, money!

BADGER WATER METERS

BADGER METER MFG. CO., Milwaukee 45, Wisconsin

"Measuring the water of the world"

(Continued from page 34 P&R)



Illinois—Alt



Minn.—Thompson

He is a registered professional engineer in Florida, Georgia, South Carolina, and West Virginia, belongs to a number of professional and technical societies, including ASCE, NSPE, the International Assn. for Hydraulic Research, the American Assn. of Engineers, and the Society of American Military Engineers. He has been president of the Florida State Board of Engineer Examiners and the Florida Engineering Society. Last year he received a Centennial Citation for distinguished service to his state from the University of Florida. A member of AWWA since 1941, he has been trustee and chairman of his section.

Illinois—Edward E. Alt, sales representative, Chicago Bridge & Iron Co., Chicago. A Chicagoan to the bone, he was born there in 1892, and, after venturing as far afield as was necessary to obtain a degree from the Massachusetts Inst. of Technology (in 1915), he returned there to work with the architectural firm of Perkins, Fellows & Hamilton. In 1918 he joined the Chicago Bridge & Iron Co. to work on the engineering and sales of steel water tanks and reservoirs.

He has been connected with AWWA since 1920, when he became the Associate Member representative for his company. In 1941 he joined in his own right, and he has been trustee and

chairman of the Illinois Section. He is a member of the engineering staff of the Joliet, Ill., branch of the Federal Civil Defense Administration, and belongs also to the Illinois Society of Professional Engineers and, on behalf of his firm, to the Water and Sewage Works Manufacturers Assn.

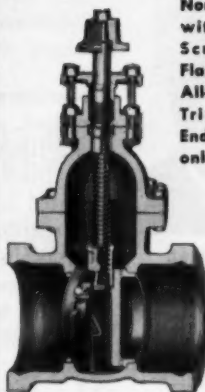
Minnesota—Leonard N. Thompson, general superintendent and engineer for the Water Dept. of St. Paul, where he was born in 1888. He was graduated from Ripon College, Ripon, Wis., in 1911, and then became an engineer for the Omaha Railway and the St. Paul Water Dept. In 1919 he served as designing engineer for the U.S. Air Service at Washington, D.C., returning to St. Paul in 1920 as engineer in charge of designing and constructing new facilities. After an interval in 1927–1928 with the contracting firm of D. W. Moore & Thompson, he returned to the Water Dept. in 1929 in his present capacity.

This is Thompson's second term as his section's national director, as he held similar office in 1937–1939. He has been a member since 1929 and served as AWWA vice-president and, president (1945–1946). He has also served his section as chairman and secretary-treasurer and was given its Fuller Award in 1949.

Montana—Claude W. Eyer, city engineer and water superintendent, Glendive, Mont. Born in Evers Grove, Pa., in 1902, he came to Glendive six years later. In 1926 he was graduated from the University of Wisconsin with a B.S. degree in chemical engineering, armed with which he went to Florida the next year as an engineer with a surveying crew. He then returned to

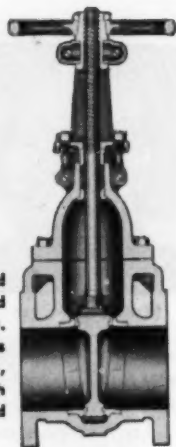
(Continued on page 40 P&R)

Crane 125-Pound Iron Body Wedge Gate Valves are an improved design, embodying many features of unusual merit. They set a new peak for quality in iron body wedge gate valves, having greater strength, longer life, and better all-round adaptability for all types of services.



Non-Rising Stem, with Hub Ends, Screwed, and Flanged Patterns. All-Iron or Brass Trimmed. Hub Ends, Brass Trim only.

Outside Screw and Yoke Screwed and Flanged Patterns. All-Iron or Brass Trimmed. Also, available with brass seats and steel stem.



See If You Don't Agree!

Here's the big value—the big selection: CRANE 125-Pound Iron Body Wedge Gates

... with quality features that assure exactly the kind of service you want. Body and bonnet are oval-shaped with extra metal where it's needed most, to provide liberal strength. Flanged patterns have tie-ribs between body and bonnet flanges. You also get a solid web-type disc with long guides ... a stem of liberal diameter with long thread engagement ... an exceptionally deep stuffing box with high-grade packing ... a two-piece ball-type gland and flange—plus an easy-to-grip handwheel with oval-shaped rim. Non-rising stem valves have a brass bushed stem collar. OS&Y design includes a brass bonnet bushing, swinging eye bolts ... and a tee-head disc-stem connection on sizes 12-inch and smaller.

Big selection includes all-iron or brass trimmed valves ... Underwriters' pattern valves, quick-opening types ... valves for process industries ... valves for marine service. Sizes up to 48-inch. Check your Crane Catalog or ask your Crane Representative next time he calls.

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

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Branches and Wholesalers Serving All Industrial Areas



VALVES • FITTINGS • PIPE • PLUMBING • HEATING

(Continued from page 38 P&R)



Montana—Eyer



Ohio—Hoffman

Glendive to become assistant city engineer and was promoted to his present post after two years, in 1929.

An AWWA member since 1931, he has been active in committee and other work for the Montana Section, becoming its chairman in 1940 and receiving its Fuller Award. He is also a member of the American Inst. of Chemical Engineers, the Montana Sewage & Industrial Wastes Assn., and the Montana Municipal League.

Ohio—L. J. Hoffman, senior associate engineer and superintendent of distribution, Water Div., Bureau of Water and Sewerage, Akron. Born in Salem, Ohio, in 1899, he studied engineering at the University of Akron, from which he was graduated in 1923. In 1927 he joined the service of the city to become assistant engineer in the Bureau of Highways, coming to the Bureau of Water and Sewerage in 1938 as office manager. He was appointed to his present post in 1951.

In AWWA, which he joined in 1939, he has been secretary and chairman of the Management Div. and secretary, vice-chairman, and chairman of the Ohio Section, receiving its Fuller Award in 1946. He is also a member of the Ohio Society of Professional Engineers, the National Society of Professional Engineers, the Akron Council of Engineering and Scientific So-

cieties, and the Akron Dist. Society of Professional Engineers, of which he has been secretary and chairman.

Southwest—J. R. Pierce, vice-president, general manager, and director of the General Waterworks Corp., Pine Bluff, Ark. Born (1903) and educated in Pine Bluff, he performed construction and engineering tasks for the Arkansas Power & Light Co. and its predecessors, beginning in 1924. In 1938 he was appointed assistant general manager of operations for the company. He became part owner of, and assumed his present duties with General Waterworks Corp. in 1942.

He has been an AWWA member since 1943 and has served the Southwest Section as vice-chairman, chairman, member of the Publication Committee for the *Southwest Water Works Journal*, and trustee of the Egmont S. Smith Memorial Scholarship Fund. He has also been president of the Arkansas Water and Sewage Assn.

Manufacturer—Carl N. Brown, sales manager—pipe, U.S. Pipe & Foundry Co., Birmingham, Ala. A much-traveled man, he was born in Newton, Mass., in 1903, attended grade school in Kansas, high school in Pennsylvania, and college in Rhode Island, receiving the B.A. degree from Brown University in 1925. He joined U.S.



Southwest—Pierce



Mfr.—Brown

(Continued on page 42 P&R)

BLOCKSON Sodium Fluoride



BLOCKSON Sodium Silicofluoride



BLOCKSON Sodium Polyphos



—a water soluble Glassy Sodium Phosphate
of standardized composition; specified for all
water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate



A leading primary producer of Sodium Fluoride
and Sodium Silicofluoride (sole producer of Sodium
Polyphos), Blockson provides a dependable high
purity source of supply for the water works trade.

SAMPLES AND DATA ON REQUEST.

BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS

(Continued from page 40 P&R)

Pipe & Foundry Co. in 1928 and worked as sales agent in Kansas City, Boston, and Chicago, where he was assistant and later western sales manager in the years from 1937 to 1950. In the latter year he came to Burlington, N.J., as assistant general sales manager for the firm, attaining his present post in 1953. Later that year he moved, along with the company's general offices, to Alabama.

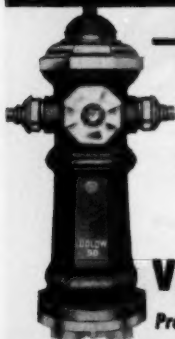
While in Chicago, he joined AWWA and was Illinois Section secretary for four years. He is also a member of the American Gas Assn. and represents his firm on the Board of Governors of the Water and Sewage Works Manufacturers Assn., of which he has been vice-president and president. He is a member of the ASA committee

for cast-iron pipe, A21, which is responsible for the many AWWA cast-iron pipe specifications.

Pakistan-bound is Dean Edward R. Stapley of the Inst. of Technology, Oklahoma A&M College, on a survey mission for the College and the Ford Foundation. The objective of the mission is to assist the industrialization effort of the government of Pakistan by surveying the technical education needs of that country. Dean Stapley will report on the education of professional engineers; other colleagues from Oklahoma A&M will consider technical institute training on a non-degree level, and finally trade schooling, in order to promote a well rounded technology.

(Continued on page 44 P&R)

NEW—MACHINE TOOLS AND FOUNDRY EQUIPMENT



—plus 94 years experience make
the difference greater than ever!

SPECIFY



VALVES and HYDRANTS

Preferred for Quality... Simplicity... Ruggedness



The LUDLOW VALVE

MANUFACTURING CO., INC.
TROY, NEW YORK

Engineering Flow Control Since 1861

Fire Hydrants	•	Mud Valves	•	Flap Valves	•	Shear Gates
Gate Valves	•	Check Valves	•	Foot Valves	•	Sluice Gates

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Dependability



Operators of Roberts-equipped water treatment plants look forward to the same trouble-free service tomorrow that they have come to count on since their equipment was installed.

Even in little things, Roberts follows through the years . . . an accidentally broken operating table handle is supplied to match the originals . . . replacement valve parts are shipped from stock or precisely made to the original pattern. Modernization of design has never obsoleted any Roberts equipment.

There has not been, or will there be, an "orphan" with the name Roberts attached. Integrity is built into every piece of Roberts equipment . . . for the years.

Roberts Filter . . . Nameplate of dependability

ROBERTS FILTER

Manufacturing Co.
Darby, Penna.

MECHANICAL EQUIPMENT
BY
ROBERTS FILTER MFG. CO.
DARBY, PENNA.

(Continued from page 42 P&R)

Mechanical salvation for the anti-fluoridationist is now at hand, reassuringly designated the "Model T." Not automotive, but almost automatic, this Model T is a "Fluorine Extractor" designed for attachment to the home water faucet, there to remove fluorides from the tap water for approximately a penny per gallon—"a mere fraction of the cost of bottled spring water." No bottles to return either—just a regeneration of the filter bed every 20 gallons, and that could be as infrequently as twice a week for the family of four careful to defluoridate only the water actually consumed.

The description of "How the Naff Model T Works" suggests that extraction is magnetic-like in principle. The extractor itself, a product of Natural Products Corp., Grafton, Wis., sells for \$19.95, and the "flushing compound" comes in \$2 and \$7 lots, supposedly enough for 3 months and 1 year, respectively. Assuming an average use of 6 quarts per day per person for drinking, cooking, and other con-

sumptive requirements, the penny per gallon estimate adds up to a mere \$5.50 per year, less than 40 times the cost of putting the fluorides in. And, of course, the bill would be considerably cheaper per person for those parents who believe that fluorides are all right for kids, but dangerous for adults. They would have to defluoridate only the water they used personally—i.e., in their portion of the ice cubes, in the pots and pans in which their food was cooked, etc. In some families this might get to be as cumbersome as a return to the old Model T age, but to escape almost any imaginable mental or physical incapacity, the price has to be right.

Not having seen, much less investigated, one of these Model T's, we cannot, of course, pass judgment on its ability to extract. Whether it does or not, though, will probably make very little difference in its effectiveness as a cure for what ails most of our antiest antifluoridationists.



A 75th birthday—that of the Geological Survey—is the occasion for this meeting with President Eisenhower of (left to right) William E. Wrather, its director; Felix E. Wormser, assistant secretary of Interior; and Interior Secretary Douglas McKay.

(Continued on page 46 P&R)

Cochrane solids-contact reactor



ECONOMICAL WATER TREATMENT

for municipal use

In addition to water softening, Cochrane Solids-Contact Reactors are used for clarification of surface waters for removal of suspended solids, turbidity, color, taste, odor; coagulation and reduction of alkalinity; removal of silica; removal of fluorides, etc.

Design of Cochrane Solids-Contact Reactors provide more completely treated water, faster, and at less cost

than conventional methods of reaction and settling. High slurry strength in the reaction zone results in optimum catalytic effect; large sludge concentrators result in minimum waste water; automatic desludging saves time and labor; chemical savings are impressive.

For complete details of Cochrane Solids-Contact Reactors, write for Publication 5001-A and reprints on Reactors.



Cochrane CORPORATION

3124 N. 17th Street, Philadelphia 32, Pa.

Representatives in thirty principal cities in U.S., Toronto, Canada, Mexico City, Mexico; Paris, France; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii

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Send me Publication 5001-A on Cochrane Solids-Contact Reactors.

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Demineralizers • Hot Process Softeners • Hot Zeolite Softeners • Dealcalizers
Reactors • Decorators • Continuous Blow-Off • C-B Systems • Specialties

(Continued from page 44 P&R)

Watching our waste line these past two months, to protect it against the engineering realities of practically puny leakage figures, we have been appalled to see it dwindle away to less than 15 per cent of its old self. And since its old self was spread all over the map—in *The Story of Water Supply* and in *Your Water Supply* to mention only two locations—the author's alterations required to accommodate our new figure have been on a par with what tailor's alterations might have been if the waste were a waist. Now that the agonies of reducing are over, though, we're happy at last to be able to put our finger on the backbone of fact.

This backbone, as developed for us by Reginald Bowering, director of the engineering division of the provincial department of health in Vancouver, B.C., is based on four principles:

1. A leaky tap produces the same results as a partly opened tap, since a leaky tap is a partly opened tap.

2. Most household taps are located 6 to 10 in. above the point where the stream of water splashes into the receptacle (i.e., the bottom of the sink).

3. In order to produce a stream of water as small as $\frac{1}{8}$ in. in diameter measured anywhere between the spout and the sink bottom, any ordinary household tap must be so throttled as to act as a pressure-reducing valve; and the pressure at the spout will be reduced to zero or almost zero, *no matter what the original pressure was*. This does not necessarily apply to the specially designed taps of small orifice sometimes found in laboratories. In taps that discharge horizontally, as from the end of a pipe, the spout will not be full, and the water flows from the tap as from an open channel. In taps that have a turned down spout such as the one illustrated in *The Story of Water Supply*, the water may flow at full bore and it will be at almost zero pressure and low velocity; and immediately upon leav-

ing the spout (usually within one diameter) the water will contract to a small stream.

4. Once the water has left the spout, each particle of water will be acted upon by gravity according to the formula

$$V^2 = u^2 + 2gS$$

Where: V = velocity, in fps, at any distance, S , from the spout

u = initial velocity at the spout

S = distance, in ft, from the spout.

It was in principle 3, particularly, that we saw our own calculations undone, based as they were on the assumption of a fully contracted orifice at 60 psi. Not only *our* calculations,

TABLE 1
Comparison of Leak Charts

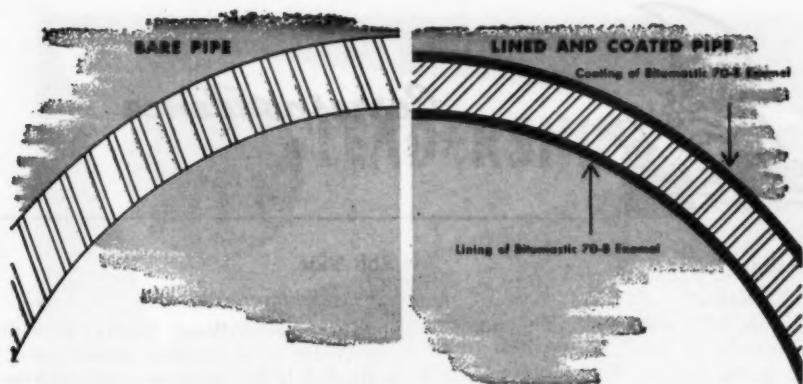
Chart	Reported Loss, gpd		
	Leak	Leak	Leak
A	165	650	2,520
B	170	970	3,600
C	175	700	2,800
D	180	720	3,600
E	264	943	3,806

either, as will be obvious from the comparison of our figures (Line C) with those of the only other similar leak charts we've been able to find given in Table 1.

General conclusions of "Bowering's Black Paper"—a seven-page engineering report, duly signed, sealed, and delivered—were:

1. The discharge from a leaky household tap, when the diameter of the stream produced is $\frac{1}{8}$ in. measured anywhere from the spout to the sink bottom, is so small that, for practical considerations, the pressure on the discharge side of the tap is zero, *no matter what the pressure is on the upstream side of the tap*.

(Continued on page 74 P&R)



It takes less wall thickness



when you protect steel pipe with
Bitumastic® 70-B Enamel

BITUMASTIC 70-B ENAMEL—when applied to a thickness of approximately $\frac{3}{32}$ "—protects the exterior of pipe from the corrosive action of the soil in which it is buried. It is much more economical to use this protective coating than to specify pipe with greater wall thickness in order to allow for future corrosion.

For instance, if it were calculated that a $\frac{3}{8}$ " wall would provide sufficient structural strength for a given pipe line, it would be unnecessary to specify a $\frac{5}{8}$ " wall to compensate for corrosion. The use of Bitumastic 70-B Enamel

would do away with the need for the additional $\frac{1}{4}$ " of steel—a substantial saving.



Besides specifying less wall thickness, you can use *smaller* pipe by applying Bitumastic 70-B Enamel to the interior. A spun lining of this coal-tar base Enamel *keeps* flow capacity high. So you don't have to buy *over-sized* pipe to allow for future "shrinkage" due to tuberculation and incrustation.

Give your community this two-way savings on your large-diameter water lines by specifying strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel. If you wish, we will handle the entire coating job for you. Write for full information.



KOPPERS COMPANY, INC.

Tar Products Division, Dept. 505-T, Pittsburgh 19, Pennsylvania

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.



Correspondence

Headlines

To the Editor:

To the hills with you! The egghead shown on p. 42 P&R, March 1954 JOURNAL, is not Willing Water.

We are not purveyors of rain. What happens to water before we get it or after we turn it loose shouldn't happen to Willing Water.

Let his head remain in the shape of a drop as it reluctantly detaches itself from the faucet, the last point of physical contact with the water system.

E. A. DEETEE

Mar. 25, 1954

From the Editor:

The out provided by your memorandum of Mar. 25 from the eggheadedness of WW is certainly most welcome. What bothers us, though, is the fact that you have "Willing" Water shaped by his reluctance.

To the Editor:

MAY BE ADVISABLE EDIT OUT
QUOTE RELUCTANTLY UNQUOTE
STOP HOWEVER WORD USED
ADVISEDLY IF UNFORTUNATELY
STOP RELUCTANT BECAUSE WW
AS DROP SLIPPED THROUGH
METER WITHOUT REGISTERING
STOP ALSO WW AS DROP WILL
PROBABLY BASH HEAD AGAINST
SINK AND FIND SELF IN SEWER
WITHOUT DOING ANYBODY ANY
GOOD STOP WILLINGNESS
WASTED STOP

E. A. DEETEE

Apr. 1, 1954

From the Editor:

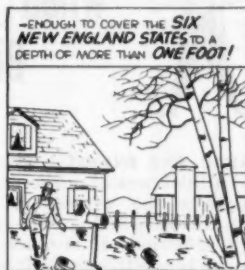
STOP!

Ebb Tide

To the Editor:

"The Story of Water Supply" by Willing Water is an excellent booklet, and I trust that it will be given wide distribution.

But on page 13, at the top, Willie refers to 17 bil gal as being enough to cover the six New England states to a depth of more than 1 ft. My calculations leave me with the conclusion that only 51,000 acres, or approximately 80 square miles, would be covered.



Perhaps you have already caught this discrepancy, but it is forwarded to show what critical review you may expect.

H. W. POSTON

Little Rock, Ark.; Mar. 18, 1954

Between the facts and their artistic rendering, somehow, somewhere, something went wrong. We're still multiplying, dividing, and square rooting around for the source of the error. Meanwhile, "—enough in a year to cause a flood a foot deep and more than 10 miles wide, all the way across the U.S." is what future editions will say. Not enough, though, to drown our sorrows.—Ed.

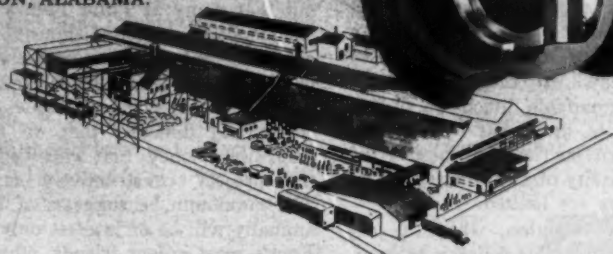
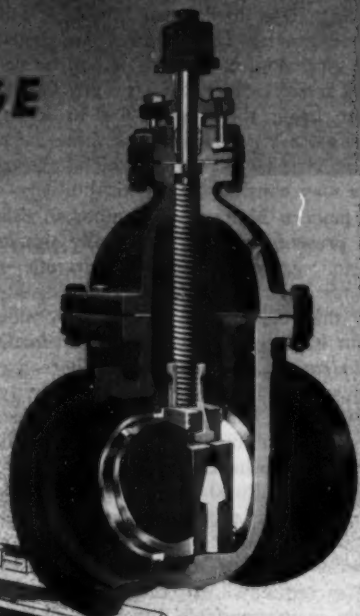


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The Reading Meter

The Limits of the Earth. Fairfield Osborn. Little, Brown & Co., Boston (1953) 238 pp.; \$3.50

If any genius can discover a way to make two drops of rain fall where but one droppeth today—and not, as our present cloud-seeders appear to do, by parching Peter to dampen Paul—he will achieve greater fame than Prometheus. That mythological worthy, it will be recalled, suffered torment for raiding Olympus to bring the gift of fire to earth. What we ask of the heavens these days, instead, is water—a change which philosophers may consider paradoxical.

A modern Malthus, the author of this book presents us with a dismally simple equation: *explosive population growth* → *need for more food*; and proves devastatingly that the factors on the other side do not balance: *limited productive lands* → *inadequate food supplies*. There are many reasons for the limited productivity of agriculture, but after allowing for those of man's own making: farming that is inefficient, or harmful to the soil; or detrimental cultural institutions, such as the use of cattle by the South African native as a symbol of wealth rather than a source of food, and the tolerance of the "sacred cow" in India—there still remain insurmountable difficulties of terrain and climate, and what Mr. Osborn calls "the stern barrier that blocks the productive capacity of any country whose water resources are limited."

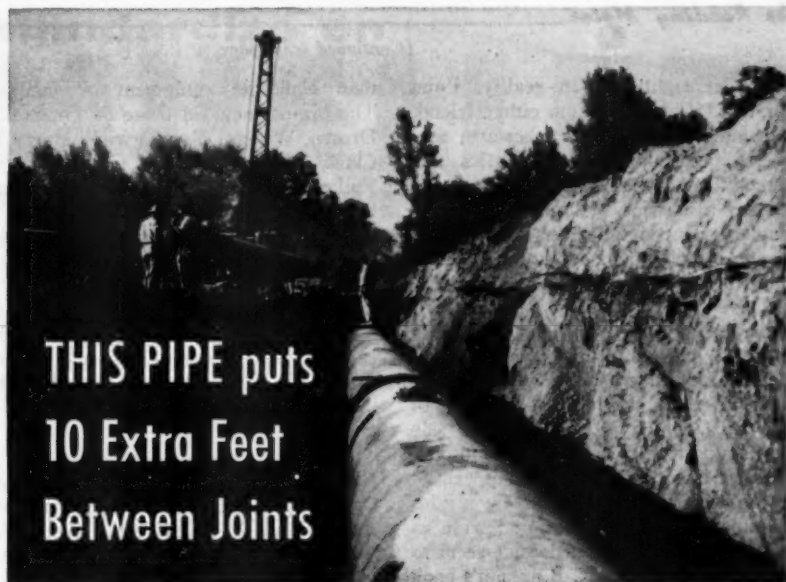
Mr. Osborn's solution, which he advances with considerable delicacy, is population control. His argument is the more persuasive because the achievements of medical and sanitation workers—including,

of course, those in our own field—have everywhere lowered the death rates and increased the pressure of numbers, especially in the "underdeveloped" regions where there were already too many mouths to feed. But there are more ways than one to tackle a problem, and, even though it may only postpone the day of reckoning, we exhort the modern rain-makers to come forward and do wonders. We only hope they meet with a kinder reward than was accorded Prometheus.

Shirt-Sleeve Diplomacy: Point 4 in Action. Jonathan B. Bingham. John Day Co., New York (1953, 1954) 303 pp.; \$4

This book is "for" Point Four; its author was deputy administrator of the Technical Cooperation Administration for a while, and the dust jacket carries an endorsement by the man who is responsible, in a political sense, for the whole enterprise—Harry S. Truman. And yet Mr. Bingham's attitude is about as hard-headed and even critical as TCA's foremost opponents could wish. He points out that many of Point Four's certainly commendable accomplishments, as reported in the press, have been exaggerated or at least oversimplified; that the job cannot be done easily or painlessly, but is costly and difficult; that on the other hand the money that can be put into the project constructively is limited. The maximum he suggests of \$1 billion annually will be of interest only to Point Four's most ardent friends, who at times seem to forget its limitations. The necessary minimum he suggests of \$500 million is approximately twice the current

(Continued on page 52 P&R)



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The Reading Meter

(Continued from page 50 P&R)

rate of expenditure. In reality, Point Four has less to fear from either friends or enemies than from its lukewarm supporters, preoccupied with politics and budgets.

In any discussion of improving the lot of underdeveloped areas, the improvement of water supplies and sanitation receives prominent recognition. AWWA members have helped in this work, and Mr. Bingham specifically mentions the accomplishments of Paul S. Fox, who becomes a Life Member of AWWA this fall. Fox is directing the health "servicio" of Costa Rica, which is producing for sale a sanitary latrine cover of wood and concrete that is so popular the plant cannot keep up with the demand. "The privies so equipped are known far and wide as 'fox-holes,' and Mr. Fox doesn't seem to mind," we are told. Mr. Bingham's book is filled with chatty success stories of this kind, but what is more important is that it is also filled with the kind of clear thinking that is essential if we are to help strengthen the underdeveloped portions of the free world in both their capacity and their desire to remain free.

Proud Heritage: *A review of the Lawrence Experiment Station. Div. of Sanitary Engineering, State Dept. of Public Health, 511A State House, Boston 33, Mass. (1953) 36 pp.; paperbound; no charge*

The history of the Lawrence Experiment Station in the years following its founding in 1886 is for all practical purposes the history of the birth and development of sanitary engineering in America. Not only have the experiments on sewage and water treatment left their indelible mark on methods still used today, but the roster of the Lawrence pioneers includes the men who were to dominate their field even after many of them had left Lawrence. As Hiram Francis Mills, who organized the project used to say, the Station invested in brains, rather

than elaborate equipment or facilities. The brains included those of Thomas M. Drown, William T. Sedgwick, Harry W. Clark, Edwin O. Jordan, George Warren Fuller, Allen Hazen, Stephen Gage, and George O. Adams. None is with us today, but their accomplishments in establishing an engineering basis for sewage and water treatment will outlast us and those who follow us. It is fitting, now that a new and modern laboratory is taking the place of the old building that Hiram Mills once worked in, that the history of the Station itself be published.

Epidemics in Colonial America. *John Duffy. Louisiana State University Press, Baton Rouge 3, La. (1953) 274 pp.; \$4.50*

A historian's account of public health in colonial times paints a dismal picture of appalling death rates and almost constant harassment from agues, fluxes, and poxes—among which our old friends dysentery and, to a lesser extent, typhoid, figure prominently, so far as contemporary descriptions permit them to be diagnosed today. It might perhaps be exaggerating a bit to say that the chief consolation of the colonists was that there were not enough doctors to attend all the sick, but certainly the routine practice of "bleeding, vomiting, purging," justified a good part of a contemporary observer's comment that "more die of the practitioner than of the natural course of the disease." In this setting, the greatest gains were made outside of the medical field, and at times—as for example was true of varioration, or inoculation against smallpox—even against the opposition of the doctors. Quarantine measures, improved diet and sanitary conditions, and the eventual survival of enough native-born children to constitute a generation which possessed immunity to many hazards and was acclimatized to most of the others, eventually eliminated illness as a chronic condition of life.

(Continued on page 54 P&R)

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The Reading Meter

(Continued from page 52 P&R)

The Utilization of Scientific and Professional Manpower: *Proceedings of a National Manpower Council conference held Oct. 7-11, 1953, at the Harriman Campus, Columbia University, Harriman, N.Y. Columbia University Press, Morningside Heights, New York 27, N.Y. (1953) 197 pp.; \$3.50*

A group of stimulating thinkers let go with their ideas on how to get the men to do the jobs, and quite a few sparks come flying from this superficially sedate discussion. Frank Pace Jr., former Secretary of the Army and Director of the Budget, has some pungent words to say on the importance of giving the men who assign other men to their jobs a sense of the importance of *their* job, and goes on to assert that often the removal of incompetents means as much to their fellow-workers as a raise or a promotion. George M. Maverick, who directs employee relations at Standard Oil Development Co., tries to find some more effective way of using engineers than simply counting old-style job openings and matching them with an equivalent number of noses—a method which the successive and severe miscalculations of our recent needs for engineering students should warn us against. A number of participants pointed to the danger of many short-sighted policies of which many professional groups or their employers are guilty—by erecting arbitrary standards or qualifications to limit their number; by refusing to train and use intelligent nonprofessionals to perform a multitude of routine tasks under qualified supervision; by failing to take full advantage of manpower or of qualified members of minority groups; by resisting delegation of duties and failing to make most effective use of the manpower available; and by failing to realize how adverse personal and even off-the-job elements can cause men to lose efficiency or change their fields.

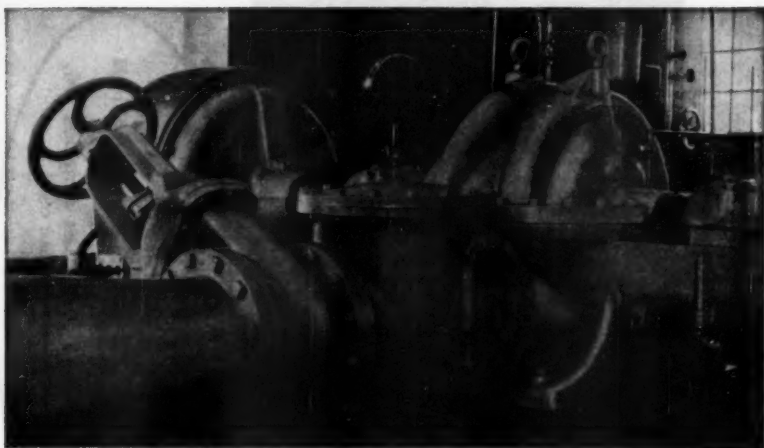
NFPA Handbook of Fire Protection (Crosby-Fiske-Forster). *Robert S. Moulton, ed. National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass. (11th ed., 1954) 1560 pp. plus ads; \$10.50*

Superseding the 10th edition of 1948, this new edition of a time-proven reference work continues the work of giving facts, statistics, and comment on the materials and methods of preventing fires and minimizing fire damage. In addition to the usual material of construction details and materials, there are tables of flow, friction loss in pipes, and similar hydraulic and engineering data. Much of this tabular material is of general reference interest, and a detailed index improves the usefulness of the volume.

Lefax Engineering Data Books. *Lefax, Sheridan Bldg., Philadelphia 7, Pa.*

Issued piecemeal as part of a standardized series, these looseleaf data sheets can be custom assembled in paper jackets, leatherette ring binders, or various types of file cabinets to meet specialized needs, or they can be ordered from prepared assemblies in major technical fields. An astonishing amount of information has been compressed on these 3¼- x 6¼-in. sheets, and the flexibility of the looseleaf arrangement combined with the pocket size make them the handiest field source of engineering reference around. Some offerings of water works interest include the Hydraulic Engineering Handbook (No. 789, \$3.50 in binder); Data Books on Hydraulics (No. 612) and Piping (No. 653; each \$1.25, in paper jacket); and a Handbook of Concrete Design (\$3.25, in binder). A group of 36 pages has also been prepared (Sec. 5, Part 5, 45¢ unbound) on water and sewage analysis, treatment, and rainfall data. The coverage is somewhat spotty and some of the data quite old, but the idea is a good one.

(Continued on page 98 P&R)



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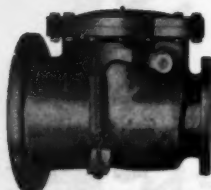
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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is pagged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH*—*Bulletin of Hygiene (Great Britain)*; *CA*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *IM*—*Institute of Metals (Great Britain)*; *PHEA*—*Public Health Engineering Abstracts*; *SIW*—*Sewage and Industrial Wastes*; *WPA*—*Water Pollution Abstracts (Great Britain)*.

CHEMICAL ANALYSIS

Colorimetric Determination of Boron in Water. R. S. GRAELLS DE KEMPNY. *Rev. Obras Sanit. Nacion (Argentina)*, 16:147:100 ('52). Purpose was to test and adopt, if suitable, colorimetric detn. of B in water with use of quinalizarin or with Chromotrope B in lieu of potentiometric method. Chromotrope B method is not sensitive for quantities of B in natural waters. Quinalizarin- H_2SO_4 method gives results close to current potentiometric method, but requires elimination of nitrates if concn. is in excess of 5 mg/l. Simplest method, with no loss of B, was found to be hydrazine-HCl method.—CA

The Volumetric Determination of Small Amounts of Bromide and Iodide in Drinking and Mineral Waters. P. HÖFER. *Gesundh.-Ing.*, 74:224 ('53). To 50-100-ml water sample add 6 ml of soln. composed of 100 g $NaH_2PO_4 \cdot 2H_2O$, 100 g $Na_2HPO_4 \cdot 12H_2O$, 100 g $Na_2P_2O_7 \cdot 10H_2O$, and 300 g NaCl dild. to 1,200-1,400 ml with distd. water. After addn. of 6 ml of 0.03-0.5N NaOCl, warm to 90° for 5-10 min. Add 6 ml of 2N formic acid and cool to room temp. After addn. of 1 ml of 1N KI, titrate released I with 0.005N thiosulfate to obtain I concn. Br concn. is detd. by adding 10 ml of 10% HCl to titrated soln. and carrying through another titration. Nitrite does not interfere.—CA

The Estimation of Calcium in Water. A. G. KNIGHT. *Chem. & Ind.*, p. 1141 ('51). In modification of Betz and Noll method for detn. of Ca, 0.2 g of mixt. of 0.5 g Naphthol Green B, 0.2 g Murexide, and 100 g NaCl is added to each 100 ml of soln. being titrated. Color change is from olive-green to cold-blue, through gray just before endpoint.—CA

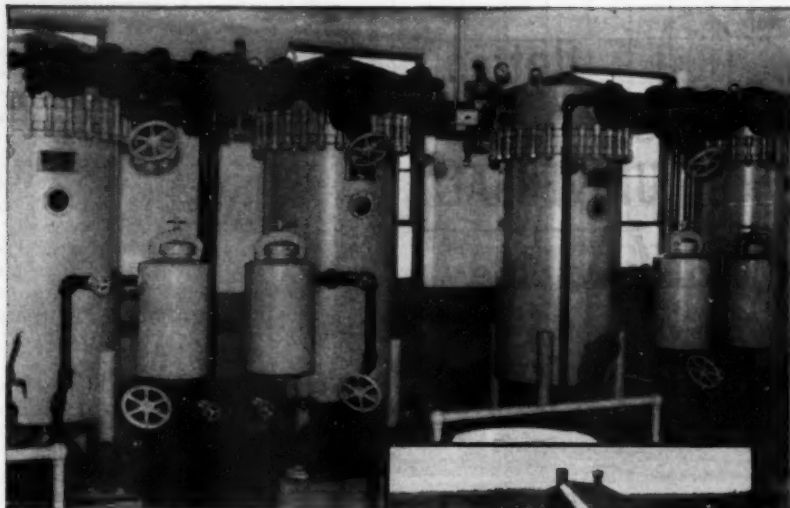
Colorimetric Determination of Active Chlorine in Sterilized Water. G. LIPPS & P. GAERTNER. *Z. Anal. Chem.*, 139:188 ('53). Slight changes in method of Ellms and Hauser with *o*-tolidine and that of Kolt-hoff with HCl soln. of dimethyl-*p*-phenylenediamine. Latter method is improved by changing concn. of reagent from 0.4% to 2%.—CA

A Simple Titrimetric Determination of Large Amounts of Active Chlorine in Water and Waste Waters. G. GAD & M. MANTHEY. *Gesundh.-Ing.*, 74:226 ('53). To 100 ml of Cl-contg. waste water under constant agitation add arsenite-methyl orange soln. Amt. of soln. added in ml is equiv. to active Cl content in mg/l. Method is adaptable to solns. contg. from 0.5 to 30 mg/l Cl.—CA

Use of Barbituric Acid for the Photometric Determination of Chlorine in Water. E. ASMUS & H. GARSCHAGEN. *Z. Anal. Chem.*, 138:404 ('53). Method described is based on Zincke-König reaction. In water contg. Cl, addn. of KCN causes this reaction: $KCN + Cl_2 \rightarrow CNCl + KCl$. If then aq. soln. of pyridine and barbituric acid is added, reaction $C_5H_8N + CNCl + 2C_4H_4$

$O_2N_2 \rightarrow NH_2CN + HCl + CO(NHCO)_2$: $CH(CH:CH)_2CH(CONH)_2CO$ takes place. Barbituric acid deriv. is reddish-violet dye which can be measured in Beckman spectrophotometer at 578 mμ. As little as 0.05 γ can be detd.—CA

A Procedure for the Routine Determination of Fluorine in Potable Waters Containing Iron, Manganese, Aluminum, and Chlorine. J. F. GRUTSCH ET AL. *J. Dental Research*, 32:463 ('53). Interferences caused by iron, manganese, and chlorine when using Scott-Sanchis reagent for fluoride detn. can



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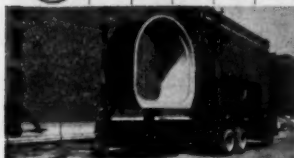
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(Continued from page 62)

be elimd. by adding thioglycolic acid (mercaptoacetic) to water samples. Ferric iron is reduced to ferrous state and complexed. Tetravalent manganese is reduced to manganous ion. Chlorine is reduced to chloride ion. Distillation will remove aluminum interference. Beakers contg. samples are heated to 70°–80°C and 3 drops of thioglycolic acid (74.6%) are added. Samples are cooled to room temp. and Scott-Sanchis reagent added. Results reported were obtained from spectrophotometric readings using 10.0-cm cells and nulling instrument at 1.4 ppm fluoride.

—F. J. Maier

Direct Titrimetric Determination of Fluoride in Natural Waters. A. M. BOND & M. MURRAY. *Biochem. J.*, 53:642 ('53). Procedure is based on direct titration of F with $\text{Th}(\text{NO}_3)_4$ soln., with Na alizarin sulfonate as indicator. Titration is carried out at pH 3.3 in presence of AcOH, and interference by SO_4^{--} , PO_4^{--} , CO_3^{--} , or HCO_3^- is eliminated by prior treatment with BaCl_2 . Reagents: fresh soln. of 0.0004M $\text{Th}(\text{NO}_3)_4 \cdot 4\text{H}_2\text{O}$; NaF standard, contg. 1 ml = 5 γ F; approx. 0.4N AcOH; approx. 0.05N NaOH; approx. 0.05N HCl; approx. 0.1N $\text{Na}_2\text{S}_2\text{O}_8$; 0.03% (wt./vol.) Na alizarin sulfonate; and 5% (wt./vol.) BaCl_2 . Procedure: Pipet 10 ml of BaCl_2 soln. into 100-ml water sample, heat to boiling, cool immediately, and filter. Measure accurately 20-ml aliquots into Nessler tubes, add 1 ml alizarin, and adjust pH so that soln. is orange-yellow. Add few drops of AcOH to lemon-yellow color, and add 1 ml more of AcOH. Remove Cl with drop of 0.1N $\text{Na}_2\text{S}_2\text{O}_8$, make up to about 50-ml vol. with distd. H_2O , and titrate dropwise with $\text{Th}(\text{NO}_3)_4$, with vigorous stirring until color matches titration blank. Make up to 50 ml before final reading (titration blank: 47.5 ml H_2O , 1 ml alizarin, 1 ml 0.4N AcOH, 1 drop $\text{Na}_2\text{S}_2\text{O}_8$, and accurately measured 0.3 ml $\text{Th}(\text{NO}_3)_4$). Ca and Mg as found in hard water do not interfere. Of 295 samples of water in Great Britain, only 7 contained more than 1 ppm of F.—CA

Determination of Microgram Quantities of Fluoride. II. Determination of Fluoride in Waters and Sewage Effluent by Means of the Aluminum-Hematoxylin Complex. J. S. BEVERIDGE, G. J. HUNTER & B. J. MACNULTY. *Anal. Chim. Acta*, 9:

(Continued on page 66)

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(Continued from page 64)

330 ('53) (in English). Detn. of F^- in sea, river, and potable waters, and in sewage effluent, by means of Al-hematoxylin reagent is described. Down to level of about 0.1 ppm, F^- can be detd. directly without prior distn., although there is some loss of accuracy for amts. of order of 0.2–0.5 ppm. With sea water, blanks should be detd. on synthetic sea water. F^- contents of number of British rivers are given, falling within range 0.06–1.09 ppm.—CA

A Rapid Titrimetric Procedure for Estimation of Fluorine in Potable Water. P. VENKATESWARLU & A. N. RAMANATHAN. Indian J. Med. Research, 40:549 ('52). Methods of F detn. were examd. for their adaptability to rapid estn. of F in potable H_2O in field. Salt-acid-Th volumetric procedure of Williams, as adapted by Smith and Gardner with few modifications, was selected. Results obtained on 31 samples of H_2O from different localities, with F content of 0.0–3.6 ppm, were in close agreement with results obtained by conventional method involving

Willard-Winter technique with subsequent titration of F^- .—CA

Polarographic Determination of Nitrates in Sanitary Analysis. M. C. RAND & H. HEUKELEKIAN. Anal. Chem., 25:878 ('53). Biol. oxidation studies on natural waters required detn. of nitrates to ascertain what portion of total O demand was due to nitrification. Polarographic reduction was carried out with 0.1N $ZrOCl_2$ as supporting electrolyte, diffusion current due to NO_3^- occurring at potential of 1.2 v against satd. calomel electrode. Detn. of NO_3^- was made by difference, current being read before and after addn. of 1N $FeSO_4$ which eliminated nitrate wave. Correction was necessary for Fe^{+++} . Method detd. nitrate N from 0.02 to 25 ppm with max. variance of 3.4%. It was applied to well waters and sewage.—CA

Polarographic Determination of Nitrate. W. A. LAWRENCE & R. M. BRIGGS. Anal. Chem., 25:965 ('53). Nitrate content of river water was detd. by using 0.1N $ZrOCl_2$ as supporting electrolyte. Reduction occurred at 1.20 v. Fe^{++} and Fe^{+++} interfered. Phosphate (as KH_2PO_4) did not interfere up to 25 ppm.—CA

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An Evaluation of the Oxygen-consumed Test. H. V. ROBERTS & W. W. SANDERSON. Sew. Ind. Wastes, 25:793 ('53). US Public Health Service dichromate oxygen-consumed test as used by N.Y. State laboratory has proved to be very useful determination. In general, it is less affected by differences in physical conditions of test situation than permanganate method and, therefore, yields more reproducible results among various samples. It has high oxidizing power and, with addition of silver sulfate, it will attack almost all compounds one would meet in sewage or industrial wastes, except benzene, toluene, and pyridine. Method has, however, one disadvantage in its use where samples have low oxygen-consumed value, such as those from unpolluted streams. As strength of dichromate and ferrous ammonium sulfate used is 0.25N, titration of 0.1 ml gives oxygen-consumed value of 4.0 ppm if maximum 50-ml sample is employed. Therefore, low oxygen-consumed values cannot be accurately determined and test would be valueless for drinking water unless it could be sufficiently adapted.—PHEA

(Continued on page 68)



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Determination of Oxygen in Waters in the Absence and Presence of Active Reducing Agents. K. WICKERT & E. IPACH. Z. Anal. Chem., 139:181 ('53). By Br difference method it is possible to det. O in presence of Na_2SO_3 , $\text{Na}_2\text{S}_2\text{O}_4$, and N_2H_4 . To oxidize reducing agent add 0.2 ml of Br soln. whose O_2 equiv. equals 99% Br/l, carry out colorimetric modification of Winkler method with MnCl_2 , NaOH , H_3PO_4 , and toluidine, then repeat without NaOH ; here MnCl_2 is not absolutely necessary. More-over Ce^{+++} can be used instead of Mn^{++} in both instances. Typical expt. is described in detail with calcn.—CA

Studies in Ozonization. A. E. RAWSON. Wtr. & Wtr. Eng. (Br.), 57:56, 102 (Feb., Mar. '53). **Part I.** Colorimetric determination of ozone with acid *o*-toluidine and volumetric estimation of gas in air and in ozonated water are discussed. Orthotoluidine method has been shown to be unsatisfactory. Colorimetric estimation of ozone using starch and KI has been investigated in detail. It is concluded that it is now possible to advance relatively easy and more accurate colorimetric method than has been available before. In colorimetric estimation with acid *o*-toluidine, yellow color developed is matched against standards calibrated with chlorine. In determination of ozone in air with KI, absorption of ozone in neutral solution of KI is most satisfactory method to employ, and weight of KI in relation to that of ozone need not be excessively high. Volumetric determination of ozone in water and in air can be carried out with neutral KI subsequently acidified with H_2SO_4 , ferrous ammonium sulfate, or sodium arsenite. One

possible method for colorimetric estimation of ozone in aqueous solution would be to match blue starch-iodide color produced by known concentrations of gas against that given by definite volumes of solution of dye of known concentration. Concentrations of ozone in aqueous solution up to about 5.0 ppm have been studied and results have been found reliable. **Part II.** Results pertaining to solubility of gas in liquid can be expressed either in terms of coefficient of solubility or as absorption coefficient. From literature available, it is not always clear if figures relate to solubility ratios or to absorption coefficients. Only attempt known by author to determine solubility of ozone in water with specific reference to water treatment is that by Hoather, who found that solubility ratio at 15°C is 0.18 and absorption coefficient is 0.17. Schone showed that when ozonated oxygen passed through distilled water, true equilibrium was not established, because one-fourth O_3 decomposed into O_2 . In laboratory scale plant employed in these experiments to determine concentrations of ozone, 1-l samples of water were withdrawn from sampling point one-third way up contact chamber through glass tube, end of which was held just below surface of liquid in standard flask to minimize disturbance. Average solubility ratio (14°–15°C) for lime-softened chalk-derived water of low organic content, using O_3 in air concentrations of order of 3–25 g/cum, is 0.29; for distilled water, using O_3 in air concentrations of order of 3–20 g/cum, ratio is 0.32. Ozone dissolved rapidly, and, up to about 25°C, saturation point was usually reached after approx. 30–60 min. At each temp. investigated, concentration of dissolved ozone

(Continued on page 70)

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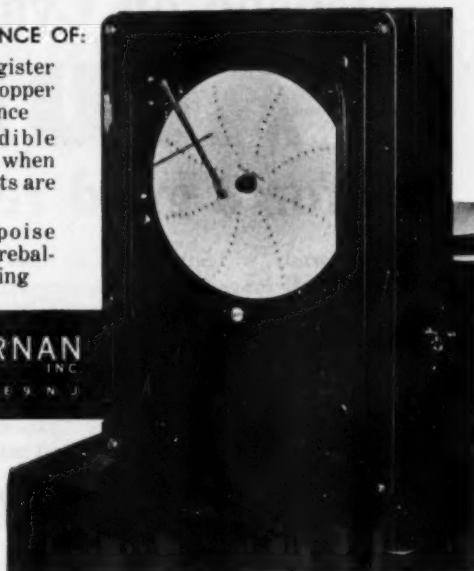
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(Continued from page 68)

is, within reasonable limits, proportional to that of ozone applied. Results suggest that ozone becomes insoluble in water at about 60°C. After equilibrium has been established, high fractional solubility ratios are maintained with contact period of only 2½ min. In plant incorporating both emulsifier and diffuser, much lower period of contact is permissible than when emulsifier is omitted.—H. E. Babbitt

Determination of Phenols in Water. G. NOISSETTE. *Eau*, 40:71 ('53). Phenol and its higher homologs, such as cresols, naphthols, etc., can be detd. by Scott's bromination method, provided that quantities of more than 1 ppm are present. Method gives good results for phenols and *o*-, *m*-, and *p*-cresols. For detection of smaller quantities or traces of phenols, 2 colorimetric micromethods are described. H₂O samples used must be analyzed within 6 hr or they must be stabilized by addn. of 1 g/l of CuSO₄·5H₂O because trace quantities of phenol in H₂O soln. are

decompd. biologically. Method based on diazo reaction is accurate for concn. of 0.02 ppm of phenol, but it is not specific for phenols, cresols, and naphthols, giving same reaction with plant tannins. Gibb's method with 2,6-dibromo-*p*-benzoquinone chloroimide has still higher sensitivity; however, preliminary purification of samples is required. This method is also suitable for analysis of sewage waters.—CA

The Determination of Small Amounts of Phenol in Waste Waters. H. W. DEINUM & W. J. HANSSEN. *Bul. Centre Belge Etude et Document. Eaux (Belgium)*, 16:102 ('52). Method of Scott was discarded as time required for max. color intensity varied from 100 min at 30° to 300 min at 20°. Method of Hinden was adopted. If 50 ml of sample is allowed to react with more than 0.2 ml of 0.1N I, sample for detn. of phenols must be distd. 10 ml of soln. contg. 100 g CuSO₄·5H₂O, 100 ml 35% HCHO, and 300 ml 4N HCl/l is added to sample, and

(Continued on page 72)

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more HCl added if necessary to make soln. acid to methyl orange. Sample is then steam distd. in app. of Parnas until 450 ml of distillate is collected. If sample reacts with less than 0.2 ml of I, 1 ml of soln. contg. 106 g Na_2CO_3 and 80 g NaOH/l is added to ppt. Ca and Mg, and portion of filtrate is used for analysis. Distillate or filtrate, contg. not more than 0.15 mg phenol, is made alk. and concd. if volume is over 70 ml. To this is added 5 ml of 1N HCl, 10 ml of diazotizing soln. [50 ml of *m*-nitroaniline (138 mg dissolved in 100 ml HCl (density 1.19) and dild. to 1 l), and 15 ml of 0.5N NaNO_2 dild. to 100 ml], 10 ml 2N Na_2CO_3 , and 5 ml 5N NaOH . Color is detd. after 5 min, but is stable for 24 hr.—CA

Determination of Pyridine and Pyridine-Base Compounds in River Water and Industrial Wastes. R. C. KRONER, M. B. ETINGER & W. A. MOORE. Anal. Chem., 24:1877 ('52). Distd. sample contg. pyridine and related compds. is buffered with AcONa between 6.8 and 8.0. Benzidine-HCl and cyanogen bromide are added, and color reaction is carried out in BuOH layer. Approx. 90 min required. Method is sensitive to about 0.005 ppm of pyridine and can be used over concn. range 0.005–1.0 ppm.—CA

Determination of Radium B in Radioactive Mineral Water. S. UMEMOTO. Japan Analyst, 2:201 ('53). Concn. and sepn. of Ra B in low radioactive mineral water by dithizone was investigated. If sample contained H_2S , decomp. it with Br water and Na_2SO_3 . To 500-ml sample, 25 γ Pb and 10 γ Bi were added, then 1 ml concd. HNO_3 was added to make pH about 2. Soln. was shaken with 30 ml dithizone in CCl_4 (0.01%) (I) for 1 min, and CCl_4 layer was discarded after 2 min. Then pH of soln. was adjusted to 9–10 by addn. of 5 ml 25% rochelle salt soln. and 6N NH_4OH , to which 5 ml 10% NaCN was added. Soln. was again shaken with 10 ml I for 1 min, and 5 min later CCl_4 layer was sepd. and was then shaken with 20 ml 1% NaCN soln. CCl_4 soln. was evapd. and dried quickly on filter paper placed on sample dish. Intensity of β -rays was measured by Geiger-Muller counter. Interferences by other radioactive daughters and accuracy of method are discussed.—CA

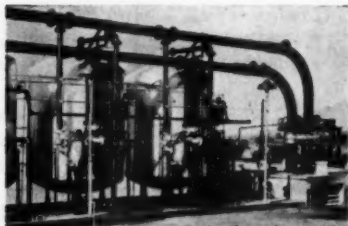
Determination of Sulfites in Water. R. MIKULA. Chemie (Czech.), 8:179 ('52). Iodometric method used heretofore has disadvantage that other reducing compds. are detd. simultaneously with sulfites. Author proposed to det. sulfites with fuchsin, whereby colorless compds. are formed. Soln. of 5.46 g basic fuchsin in 1 l distd. H_2O (1 ml = 0.05 mg SO_2) was used. Sensitiveness of new method is 0.025 mg SO_2 in 1 l H_2O .—CA

Estimating the Tritium Content of Tritiated Water. W. A. JENKINS. Anal. Chem., 25:1477 ('53). H^+ content in waters is assayed by measurement of activity of NH_4Cl which has reached exchange equil. with water samples. Known amt. of tritiated water is allowed to stand for 10 min with 1–2 g NH_4Cl . Water is then distd., and solid residue is heated until dense vapor fumes appear. After cooling, salt is ground up and sublimed. Infinitely thick sample of NH_4Cl is assayed for β -activity in windowless flow counter. By utilizing counter similar to that of author, investigators can est. activity of tritiated water sample with accuracy of 85% by using author's values for ratio of activity of solid compd. to activity of HTO.—CA

Methods for the Spectrochemical Determination of Traces. I. Analysis of Waters. F. A. POHL. Z. Anal. Chem., 139:241 ('53). Complete details of procedure are given and photographs of some of spectra shown. By mixt. of org. reagents (diethyldithiocarbamate, 8-quinolinol, and dithizone) it was possible to effect considerable concn. of approx. 40 elements studied. Complete analysis can be carried out in 1 working day, and, for detg. as little as 1 γ /l of element, 1 l of water suffices.—CA

Water. S. K. LOVE & L. L. THATCHER. Anal. Chem., 25:65 ('53). This annual review of new and improved analytical methods developed during past year for use in water analysis, like its predecessors, is "must reading" for all chemists engaged in testing of water, sewage, and industrial wastes. Emphasis in this field during past year was directed toward greater accuracy and sensitivity through revised procedures and instrumentation. More and more methods employing such instruments as photometer, colorimeter, spectrophotometer, flame photometer, polarograph, spectrograph, fluorimeter,

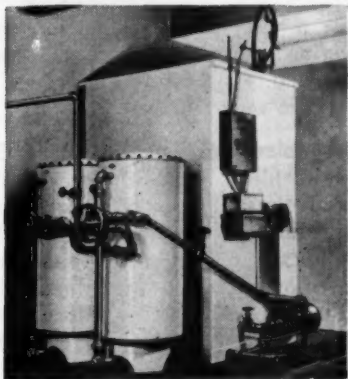
(Continued on page 74)



ZEOLITE (Ion Exchange) SOFTENERS remove total hardness. Reduce iron and manganese. Permutit multiport-valve control is fully automatic! Saves operator's time . . . increases efficiency.



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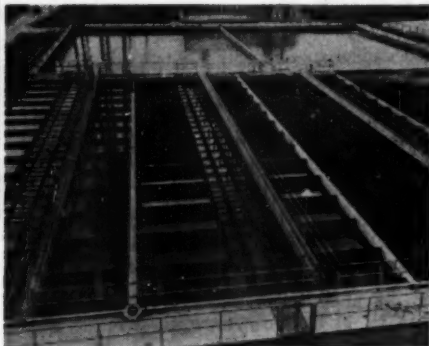
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PERMUTIT will make a free analysis of your city's water supply and make recommendations to you or your consultants. Remember—only Permutit manufactures both ion exchangers and all types of water conditioning equipment.

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Water Conditioning
Headquarters for Over 40 Years

(Continued from page 72)

etc., have been described in literature. Short descriptions of new methods of analysis and references to literature are given for all substances commonly tested for in waters, as well as for beryllium, thallium, thorium, germanium, uranium, etc. Procedures discussed in some detail include compleximetric titrations with ethylenediaminetetraacetic acid; flame photometric determination of alkali metals; new developments in fluoride determination; new developments in silica determination; use of DO determination in measurement of photosynthetic activity in sewage purification; oxygen-consumed and BOD tests; determination of phenol and phenolics; and determination of radioactivity. —PHEA

The Determination of Sediments in Suspension in Water by Adsorption Upon Diatomaceous Earth. M. SAINCLIVIER & L. BERTHOIS. *Compt. Rend.*, 236:621 ('53). For complete adsorption of 20-200 mg of suspended matter in natural waters, 250 mg of oven-dried (105°) diatomaceous earth is added to sample. Results can be reproduced to about 2%. —CA

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

How a Water Supply Was Designed for a Permafrost Area. J. R. WALLACE JR. *Pub. Wks.*, p. 64 (Jan. '54).

Scientific Water Development Versus "Dowzers" in San Clemente Contest. L. E. BLAKELEY & J. F. STICKEL JR. *Western City*, 30:1:32 (Jan. '54).

The Impact of Changing Price Levels on Rate Making. A. H. DEAN. *Pub. Util. Fortnightly*, 52:817 (Dec. 3, '53).

A Nomograph for Evaluating the Significance of Test Results. CHOU HSIUNG LI. *ASTM Bul.*, No. 194, p. 74 (Dec. '53).

Water Supply Developments During the Year 1953. M. B. CUNNINGHAM. *Wtr. & Sew. Wks.*, 101:1 (Jan. '54).

The Present Price Level Is Here to Stay. P. W. McCracken. *Pub. Util. Fortnightly*, 53:81 (Jan. 21, '54).

How to Trace Ground Water Flow. ANON. *Pub. Wks.*, p. 75 (Feb. '54).

(Continued from page 46 P&R)

2. The discharge bears no resemblance to the discharge from a sharp-edged orifice in a water pipe.

3. The discharge from the leaky tap flows in accordance with well-known principles concerning falling bodies acting under the influence of gravity.

4. Experimental confirmation of the theory can be made easily with ordinary facilities available in any engineer's basement.

5. The leakage from a tap producing a stream $\frac{1}{8}$ in. in diameter depends upon where the diameter of the stream is measured, but, in any case, the maximum will probably not exceed 350 gpd (equivalent to measurement at about 8 in. below the spout).

Crushed by the weight of engineering evidence, we have already made a change in *Your Water Supply* and are preparing to revise the next issue of *The Story of Water Supply* to read:

$\frac{1}{32}$ " leak wastes 25 gallons in 24 hours

$\frac{1}{16}$ " leak wastes 100 gallons in 24 hours

$\frac{1}{8}$ " leak wastes 400 gallons in 24 hours

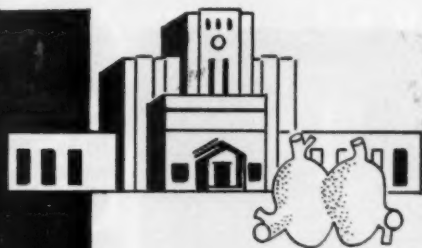
—just a wee bit higher than friend Bowering's suggestion, but nice and round and easy to remember, as a waste line ought to be.

On microfilm, the entire 1953 JOURNAL fills a spool which, with its protective carton, occupies a space less than 4 in. square and $1\frac{1}{4}$ in. thick. This microfilm edition has just been released by University Microfilms, 313 N. First St., Ann Arbor, Mich., and is available to regular JOURNAL subscribers and AWWA members at a cost of only \$7.65. The following earlier years are also in stock, at the prices shown:

1949	\$6.25	1951	\$6.35
1950	\$8.00	1952	\$7.95

Orders should be sent directly to the firm at Ann Arbor. Requests for information about inexpensive viewing equipment are also invited.

(Continued on page 76 P&R)



HOW TO PREVENT WATER WORKS "ANGINA"

Water works "angina" is a somewhat humorous term applied to failure of the pipe in a water distribution system. But the trouble, expense and lack of service is no joke.

There is a sure cure for water works "angina". It consists of a thorough application of McWane-Pacific cast iron pipe—bell-and-spigot or mechanical joint. The best method, however, is to prevent this dread trouble by laying cast iron pipe in the first place—because cast iron pipe lasts for centuries of service underground.

Modern cast iron pipe is better than ever before because McWane-Pacific Super-DeLavaud pipe is made under a modern quality control system of raw materials, manufacturing process and finished product. Write or wire for details. McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama. PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)

**McWANE
PACIFIC**

Lasts for Centuries

(Continued from page 74 P&R)



A new chlorinator (above), the A-701, has been introduced by Wallace & Tiernan, which is showing it for the first time at the AWWA Conference in Seattle, on May 23rd. The instrument features a dual orifice meter to offer feed ranges of up to 100 to 1; linear scale readings; and electric, hydraulic, air, or vacuum automatic control. The maximum capacity of the unit is 1,000 lb in 24 hr.

The highwaymen who have been causing water works men such grief in expensive relocation of their facilities are at least playing the field. Consider, for instance, the case of homeowner John Scuba of Richfield, Ohio. John, who moved to Richfield in 1950 "because it was so peaceful and quiet," was just beginning to get the feel of his new \$35,000 brick home when an Ohio Turnpike cloverleaf moved in. Next thing he knew, his 94-ton structure had been trundled off a half-mile south—"the biggest house ever moved

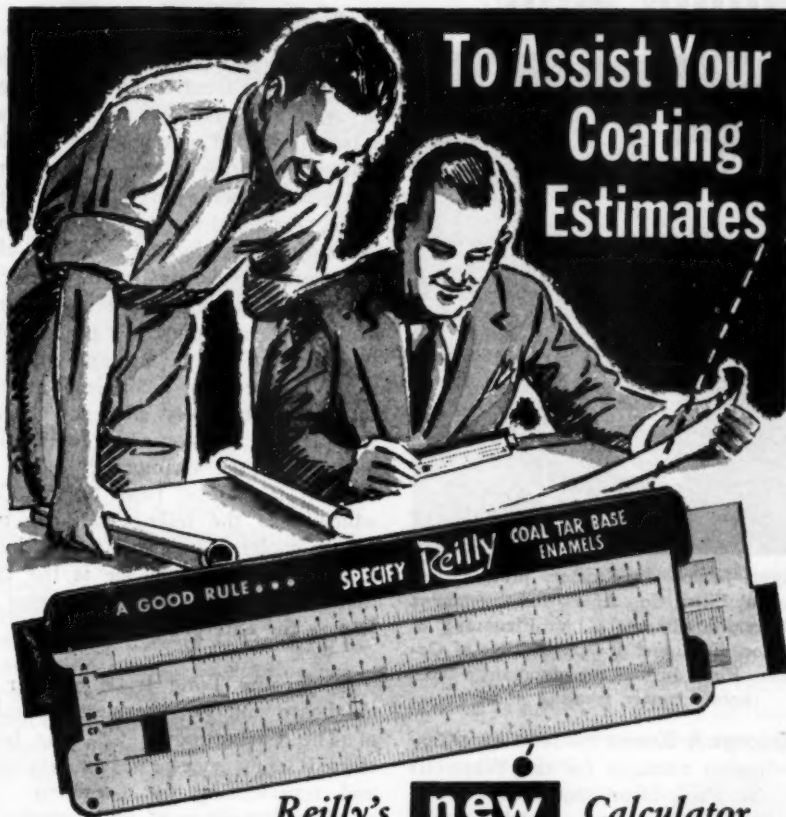
on an Ohio highway." That was last August, so that by March the family was well on its way toward adjusting to its new surroundings when "upsadaisy" once again—this time to make room for the two extra lanes that were to convert Route 21 to a *superhighway*.

Presumably John can have no complaint. His relocations are being paid for out of highway funds—just exactly what AWWA and representatives of other utilities are now trying to get Congress to legislate for them. Although changes on the system map are considerably easier to make than changes in home address and family habits, however, we have an idea that even legislative relief isn't going to eliminate all that's harrying about the highwaymen. Not to resort to name calling, we can still point out that a harry with some jack is certainly going to be preferable to the harry and bill now plaguing utilities the country over.

Robert E. Clancy of Baraboo, Wis., has been appointed sales representative of Neptune Meter Co. in Wisconsin and Upper Michigan.

New Mueller Co. sales managers include W. R. Augustine in the central states, Dan R. Gannon in the Southwest, and A. D. Parks in the Southeast. Newly assigned sales representatives for the Decatur, Ill., firm are: Richard C. Sponsler in the Middle Atlantic region; Robert B. Herrin in Missouri, replacing Robert T. Whitehead, retired; G. A. Smith in southern Illinois, replacing George White, retired; Francis X. Uhl in western Pennsylvania; Robert H. Gamble in eastern Michigan; Ray E. DeWeese in Tennessee, replacing Floyd V. Johnson, retired; and Robert J. Cope in Kentucky.

(Continued on page 78 P&R)



The illustration shows two men in a professional setting. One man is standing and leaning over a desk, pointing at a document. The other man is seated at the desk, looking up at the standing man. On the desk is a large, complex slide-rule calculator. The calculator has multiple scales and is labeled with "A GOOD RULE...", "SPECIFY Reilly", and "COAL TAR BASE ENAMELS".

To Assist Your Coating Estimates

Reilly's new Calculator

You can't afford to be without this Reilly Coal Tar Base Enamel quantity calculator to serve as your handy portable guide. Complete with estimates for enamel requirements on two grades of Reilly Primer, the tables also furnish valuable information on coupling compounds, recommended temperatures for application and quantities required for hand application of Reilly Coal Tar Base Enamels.

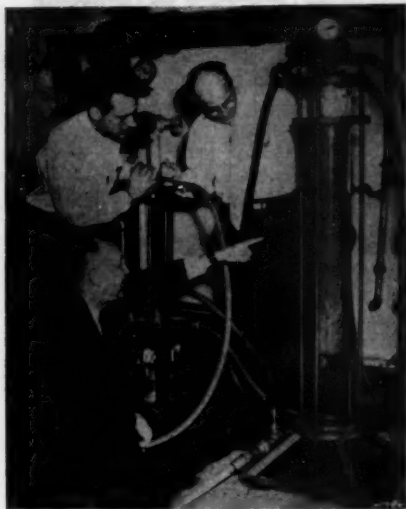
Send for your Reilly Calculator today.



REILLY TAR & CHEMICAL CORPORATION

MERCHANTS BANK BUILDING
INDIANAPOLIS 4, INDIANA

(Continued from page 76 P&R)



Mayor Joseph P. Lawlor, president of General Filter Co., Ames, Iowa, explains a diatomite filter to C. V. Flemming of London, Ont., and Joseph Phillips of Orlando, Fla., during the company's fifth annual water treating clinic.

George A. Evans has been appointed production manager for the Waterous Co., St. Paul, Minn., succeeding A. C. Wedge. Previously he had been general superintendent of the Montgomery Ward Springfield, Ill., plant, at which water pumps, cream separators, and similar products are made.

Water's powers, which we've been neglecting to mention of late for fear of sounding oversold on our own wares, have just now received the ultimate in accolades. "Pure, cool, water," the world is being told, "means better office, store, and factory morale—more sales, more production." What else this than the credit we rightly deserve for making possible America's world leadership in industrial production? And isn't it just about time that the water cooler was recognized as the symbol of business efficiency rather than a mere trysting place for the indolent and the enamored? And so what if the Great Bear Spring Co., which does the telling, sells electric water coolers—isn't a fact a fact? Only trouble we can see is the fact that the water is too close to being as free as the enterprise it fosters.

F. Jerome Tone Jr., a member of the board and vice-president for sales of The Carborundum Co., has been elected senior vice-president, assisting and representing the president. In another development, Frederick T. Keeler was appointed director of sales for the company and its subsidiaries. Previously he had been director of the Marketing Branch of the Sales Div.

(Continued on page 80 P&R)

Filter Sand and Gravel

Well Washed and Carefully Graded to Any Specification.

Prompt Shipment in Bulk or in Bags of 100 lb. Each

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how much does it cost to stand- pat?

It isn't often that a new development comes along that affects chlorine handling—in fact, not in the past 35 years has there been news as important as this to you and your community.

You may feel it costs you nothing to let new developments in chlorine handling go by the board.

But it costs your community plenty—in money, in better chlorination and in better, safer handling methods.

An Entirely New Way To Chlorinate

Not in 35 years has such a completely new, easy operating, dependable and economical chlorinator been made. The reason is that materials that could remain inert to corrosion were not yet invented.

The most positive way to chlorinate is by means of the diaphragm regulator principle. But until these corrosion resistant materials were invented, a regulator could not be made that lasted against corrosion. The regulator principle is successfully used in the F & P

chlorinator, along with such new products as Uscolite, Kel-F, Hastelloy, Teflon, and such timeless materials as silver and tantalum.

Old fashioned, out-of-date chlorination equipment uses vulnerable water seals, whereas in the F & P unit, chlorine is always handled in fully enclosed, tightly sealed, corrosion resistant pipes and components.

You owe it to yourself and your community to know about this dependable, safe, less costly way of handling chlorine. Complete facts, fully illustrated, will be sent to you if you will request them now as well as free trial offer and facts on one year IRON-CLAD guarantee.



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complete process instrumentation
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Company owned sales and service branches strategically located throughout the world.

(Continued from page 78 P&R)



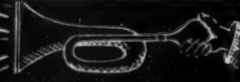
Hydraulic lift was the caption the newspapers gave this proof that water really is a jack of all trades. A woman driver, of course—who sheared off the hydrant, supposedly to avoid hitting another car. And, as might be expected, she climbed out wet but unhurt, leaving the car to settle down, wet but unhurt, straddling what remained of the hydrant. It took a man, though, to engineer the hydraulic flip that, an hour later, smashed the car over on its side when an attempt was made to pull it off its perch by tow truck. No one, of course, thought to notify the water department to save the car, or even all that good Los Angeles water. She might better have hit the other woman's car!

Ralph B. Wiley, head of the School of Civil Engineering and Engineering Mechanics at Purdue University, is retiring June 30 after 46 years of distinguished service on the faculty. Originally an instructor in hydraulics,

he was appointed to his present post in 1937 and was made director of the Joint Highway Research Project as well, in 1939. He is also chairman of the Indiana Stream Pollution Control Board and a member of the Indiana Flood Control and Water Resources Commission. Always active in technical societies, he has been chairman of the Indiana Section AWWA and is receiving its Fuller Award this year. He will be succeeded by Kenneth B. Woods.

Continuous resin regeneration is featured in the Dorrco Hydro-Softener, an ion-exchange unit with a capacity range from 75 to 800 gpm, depending on the hardness of the raw water and the combinations of cells used. The softening cells come in sizes ranging from 6 to 12 ft in diameter, in 2-ft steps; regeneration cells are 15, 22, and 30 in. in diameter. Further details may be obtained from the Dorr Co., Barry Pl., Stamford, Conn.

(Continued on page 82 P&R)

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 WHEN THE FIRST HYDRO-TITE JOINTS
 WERE BEING POURED -

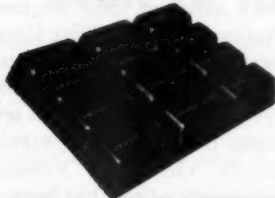
HYDRO-TITE
 (POWDER)



HYDRO-TITE
 (POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

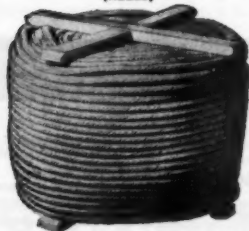
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 (LITTLEPIGS)



HYDRO-TITE
 (LITTLEPIGS)

The same dependable compound in solid form—packed in 50 lb. cartons—2 liters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX
 (REELS)



FIBREX
 (REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

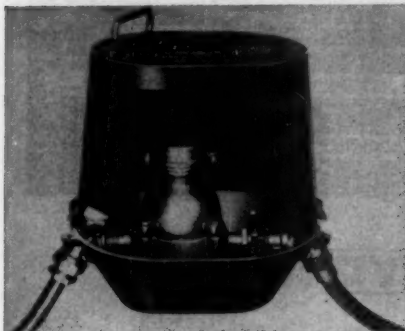
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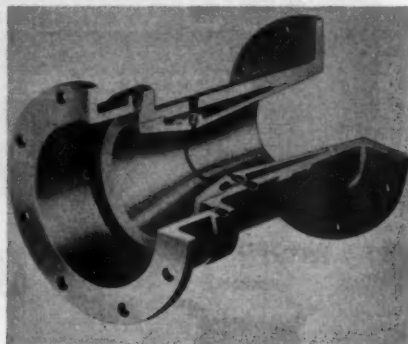
Chicago Office 100 W. Madison Street, Evanston, Ill.

(Continued from page 80 P&R)



The Yokebox, a new cast-iron meter housing for shallow or warm climate settings (above), has just been produced by Ford Meter Box Co. The three-piece device has connections that fasten to the water lines on the outside and form a solid meter yoke with valve on the inside, to fit $\frac{3}{4}$ -in. or $\frac{5}{8} \times \frac{3}{4}$ -in. meters. The top lid is flat for flush installations, and may be provided with a lock for opening with a key-handle (shown), or without a lock for opening with a magnetic lid lifter.

Jack B. Graham, chief of the Water Utilization Section, Water Resources Div. of the Geological Survey, has joined the staff of Leggette & Bra-shears, consulting ground water geologists of New York.



The Dall Flow Tube (above) has been developed by Builders-Providence, Inc., for metering liquids and gases carrying no settleable solids. The device is claimed to give the lowest permanent head loss of any known pressure differential producer of the velocity increaser type.

Robert C. Dennett and **Harry E. Newell**, both assistant chief engineers with the National Board of Fire Underwriters, have been made consultants to the Board. Both are Life Members in AWWA and have done much work on municipal fire protection surveys. Simultaneously, **George J. Robinson**, senior engineering editor, has been appointed an assistant chief engineer.

(Continued on page 84 P&R)

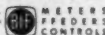
IT PAYS TO SAY

BUILDERS PROPELOFLO

THE MAIN LINE METER manufactured to Builders' traditional quality standards. Accuracy is within 2% over a wide range. Low loss-of-head. As easy to install as a valve or fitting. For Bulletin 380-K4, write Builders-Providence, Inc., 365 Harris Ave., Providence 1, R. I.

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DIVISION OF B-I-F INDUSTRIES, INC.

METERS
PRESSURES
CONTROLS

- More power and accuracy from Venturi body design
- Clear-view plastic totalizer bonnet
- Extra strong Meehanite iron body and cover
- External grease fitting on all models



When you buy **HYDRANTS** and **VALVES** for your city waterworks system...

LOOK TO THE YEARS AHEAD, TOO!

EDDY can supply replacement parts for any Eddy Valve or Hydrant ever installed! This is important to you because the Valves and Hydrants you buy today must serve several generations yet unborn. You want no "orphans" in your system. Eddy Hydrants and Eddy Valves are backed by Eddy Valve Company's 104 years of dependable operation—your assurance that replacement parts will be available during the years to come.

EDDY Bronze-Mounted HYDRANTS are built for dependability and lasting service. They open smoothly with the pressure and close without water hammer. One man can easily remove all operating mechanism for inspection and repair. Positive drip action automatically drains the standpipe, safeguarding against freeze-ups. Stem held in place below main valve means no water loss due to a bent stem.

EDDY Bronze-Mounted GATE VALVES offer simplicity of design, trouble-free operation and enduring service. From the engineering drawing boards through all stages of manufacture, they are step by step a truly "finished" product of workmanship. These factors, added to personal experience, are reasons why progressive water works men have relied on Eddy Valves for years.

Eddy Hydrants and Valves are available with bell, flange or mechanical joint connections to fit any existing or planned installation.

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EDDY VALVE COMPANY
A Subsidiary of James B. Clow & Sons

WATERFORD, NEW YORK

(Continued from page 82 P&R)

Top-hole is how the Brighton Corporation Waterworks found the public relations techniques described by F. A. McCanlies in last May's issue of the JOURNAL. And ripping was the response of both public and press when they were tested.

Occasion for the test came when F. Needham Green, the engineer in charge, had 600 ft of line to lay through the busiest part of town. Following McCanlies' suggestions, he planned the job to minimize the total inconvenience; sent a letter to the 80 customers directly affected, describing the job and offering to render assistance in any emergency caused as well as to adjust the operations to their habits wherever possible; then completed the job on schedule despite an unplanned for blizzard. During the work, notices were posted at the site to give sidewalk superintendents all the details of the job, and one man was detailed to the task of keeping the sidewalk clean. And when the job was over, the results were not only better service, but friendlier customers and a lot of free publicity in seven different newspapers that gave the public relations end of the operation friendly coverage.

Still another result, no doubt, was the advertisement which appeared in the Omagh, Northern Ireland, newspaper shortly after that: "WANTED—Man with loud voice." The job—telling housewives when the water supply is to be cut off.

Top-hole or top of the lungs, though, the need for telling as well as serving the public is universal.

New directors have been elected to three divisions of B-I-F Industries, Inc., of Providence, R.I. John R. Hartley, vice-president; F. H. Cary, chief engineer; R. W. Pearce, manager

of Chlorinizer sales; Fred W. Deutsch, manager of standard and engineered products; and Milford E. Rogers, project engineer; have been elected to the Builders-Providence board. Elected to the board of Omega Machine Co. was its sales manager, Roland J. Leveque; and George W. Kelsey, vice-president of the parent company, was elected to the Proportioners, Inc., board. Z. Chafee has retired as board chairman for the parent company and has been succeeded by H. S. Chafee, formerly treasurer. The new treasurer is C. V. Raymond.

Graver Water Conditioning Co. appointments announced recently include those of A. J. Soriente as project engineer in the Cold Process Equipment Section; C. W. Miller as Iowa representative, with headquarters at 204 N. 3rd St., Marshalltown; James J. Hanratty as New York district sales engineer; and E. A. Strahlendorff as chief estimating engineer.

Robert T. Browning, formerly director of sales and secretary of W. C. Hardesty Co., a Wallace & Tiernan Inc. subsidiary, has been appointed vice-president in charge of sales for the parent company. Other Wallace & Tiernan appointments in the sales department are those of William A. Hockett, formerly manager of the Export Div., as director of sales for the W&T Div.; Russell C. Clement, formerly Newark division manager responsible for the Northeast, as manager of field sales and service; and Vincent Pisani, of the main sales office, as manager of departmental sales.

Robert M. Collie has been admitted to partnership in the Houston consulting firm of Freese, Nichols, and Turner.

(Continued on page 86 P&R)

Check

Are You Using a
COAGULANT
with These Advantages?

✓ ① Coagulation over wide pH ranges, color, turbidity and manganese removal.

✓ ② Rapid flocculation and rapid settling.

✓ ③ Increased filter runs.

✓ ④ Quality effluent low in iron and aluminum.

✓ ⑤ Excellent taste and odor control.

FERRI-FLOC brings you these superior features and more. It will coagulate waters and wastes over wide pH ranges as well as provide excellent

flocculation in softening systems. FERRI-FLOC may be easily and safely handled in any type of standard equipment.

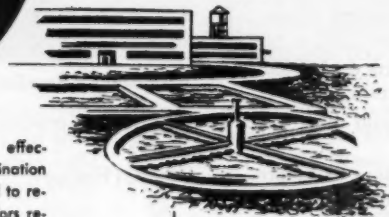


Water Treatment

Coagulation of surface or well waters. Aids taste and odor control. Effective in lime soda-ash softening. Adaptable to treatment of nearly all industrial water or wastes.

Sewage Treatment

Coagulation over wide pH range. Efficient operation regardless of rapid variations of raw sewage. Effective for conditioning the sludge prior to vacuum filtration or drying on sand beds.



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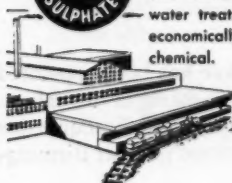
SULPHUR-DIOXIDE
HIGHEST QUALITY
SO₂

SULPHUR-DIOXIDE is effectively used for dechlorination in water treatment and to remove objectionable odors remaining after purification.

COPPER SULPHATE

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COPPER SULPHATE will control about 90% of the microorganisms normally encountered in water treatment plants more economically than any other chemical.



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(Continued from page 84 P&R)

The Third Congress of the International Water Supply Assn., to be held in London the week of July 18, 1955, is the subject of considerable preparation by the association's Programme Committee. Nine topics have been selected and assigned to persons known as general reporters, each of whom is to assemble information on his topic from numerous national reporters and then produce a report on new developments and current practice and opinions on the subject. The reports will be published in either English or French, with a summary provided in the alternate language, and are scheduled for distribution in advance of the Congress, so that delegates may discuss them at the section meetings. Afterwards the reports will be republished together with the proceedings of the meetings. The topics and general and United States reporters follow:

Harold T. Rudgal, vice-president of the Gary-Hobart Water Corp. of Gary, Ind., died on Feb. 25 after suffering a sudden heart attack. He was 50. Until 1940 a member of the engineering staff of Alvord, Burdick, and Howson, he had been superintendent of the water and sewage plants at Kenosha, Wis., before coming to Gary in 1951. His death occurred a scant two months before the opening of a filtration plant for which he had worked so diligently.

Walter L. Leach, consultant and partner in Havens & Emerson of New York and Cleveland, died suddenly from a heart ailment on March 5, at the age of 53. A partner in the firm since 1951, he had been associated with it and its predecessors since 1923. During World War II he was deputy director of the War Production Board's Water Div.

TOPIC	REPORTERS	
	GENERAL	U.S.
1. Water hammer protection	C. Dubin (France)	S. Logan Kerr
2. Pumping station equipment	H. R. Lupton (U.K.)	Richard Hazen
3. Storage tank design and construction	H. Bjorklund (Sweden)	{H. O. Hill (steel) R. C. Kennedy (concrete)
4. Aeration and iron removal	L. H. Louwe Kooymans (Neth.)	S. T. Powell
5. Safety factors in supply and distribution systems	A. Vibert (France)	C. H. Capen
6. Leak detectors and other electronic apparatus	R. E. A. Despiegelaere (Belg.)	E. S. Cole
7. Slow vs. rapid filters	A. Van de Vloed (Neth.)	N. J. Howard (Canada)
8. Training of operators	H. R. Davenport (U.K.)	Fred Merryfield
9. Methods of charging for water	E. Sherman Chase (U.S.)	

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NEW MEMBERS

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Adams, John W., Supt., Water Works, 124 E. Main St., Carlinville, Ill. (Apr. '54) *P*

Atiello, Leo, Asst. Engr., Board of Water Supply, 712 Washington St., Utica 2, N.Y. (Apr. '54) *D*

Anderson, Thomas P., San. Engr., State Board of Health, Water & Sewage Sec., Columbia, S.C. (Apr. '54) *P*

Atkinson, Ned, Supt., Water Works, Vandalia, Ill. (Apr. '54) *MP*

Baker, Luke, Water Supt., Lake Worth Village, Route 2, Box 170, Fort Worth, Tex. (Apr. '54) *MPD*

Ballenger, H. H., Supt. of Streets & Water, Twin Falls, Idaho (Jan. '54) *M*

Barnesville Water Dept., R. S. Barron, Supt., Barnesville, Ga. (Munic. Sv. Sub. Apr. '54) *PD*

Barron, R. S.; see Barnesville (Ga.) Water Dept.

Bernascone, George A., Supt. of Public Works, Water Dept., 408 Morrissee Ave., Haledon, N.J. (Apr. '54) *MRP*

Bishop, Willard A., Supt. of Distr., Water Dept., City Hall, Kansas City, Mo. (Apr. '54) *M*

Blxby, Donald T., Dist. Mgr., DeLaval Turbine Pacific Co., 535-1st Ave. W., Seattle 99, Wash. (Apr. '54)

Blakesly, Frank H., Branch Mgr., Levingston Supply Co., Inc., Alexandria, La. (Apr. '54) *D*

Bland, James W., City Engr., City Hall, Statesboro, Ga. (Apr. '54)

Boyd, James S., Civ. Engr., E. M. Freeman & Assocs., Continental American Bank Bldg., Shreveport, La. (Apr. '54) *RP*

Brackett, Mason D., Foreman, Water Works, 651-14th St., N.W., Atlanta, Ga. (Apr. '54) *M*

Braga Soares da Cunha, Helió, Chief Engr., Eng. & Designs Div., Armo Industrial E Comercial S/S, Rua da Alfandega 107, Rio de Janeiro, Brazil (Jan. '54) *D*

Bratcher, Stroud, Caterpillar Tractor Co., R.R. 1, Washington, Ill. (Apr. '54) *M*

Brundrett, Elmo H., Sales Engr., Johns-Manville Sales Corp., 3115 Blodgett, Houston, Tex. (Apr. '54)

Bruns, Melvin E., Supt., Water Works, 2511 Wallace Dr., Flossmoor, Ill. (Apr. '54) *MRP*

Buckingham, Robert A., Public Health Engr., Tennessee Valley Authority, 725 Edney Bldg., Chattanooga, Tenn. (Apr. '54) *RP*

Calrns, Kenneth C., Engr., Royal Canadian Air Force, Dept. of National Defence, 265 Daly Ave., Ottawa, Ont. (Apr. '54)

Citizens Domestic Water Co., Samuel K. Rindge, Pres., Box 577, Arlington, Calif. (Corp. M. Apr. '54) *D*

Clancy, Robert E., Neptune Meter Co., 4048 W. Taylor, Chicago, Ill. (Apr. '54) *M*

Clark, Leo R., Water Supt., Carroll, Iowa (Apr. '54) *MPD*

Collins, Glenn D., Salesman, Tower Supervisor, Gano F. Culwell Corp., 6412 Orchard Ave., Box 351, Bell, Calif. (Apr. '54) *D*

(Continued on page 90 P&R)

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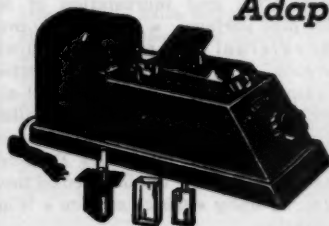
(Continued from page 88 P&R)

- Collins, Willis E.**, 764 Main St., Glen Ellyn, Ill. (Apr. '54)
- Cotton, James W.**, Supt., Water Works, Paris, Ark. (Apr. '54) *RP*
- Coupe, Rodger**, Borough Engr. & Water Supply Supt., North Caldwell, N.J. (Apr. '54) *MR*
- Couture, Louis P.**, Town Engr., City Hall, Ste. Foy, Que. (Apr. '54)
- Cralk, Donald H.**, Mgr., Midland Borough Water Co., 10th St. & R.R. Lane, Midland, Pa. (Apr. '54) *MRPD*
- Davis, Thomas J.**, Supervisor, Water Plant, Burlington Mills Corp., Box 481, Shannon, Ga. (Apr. '54)
- Delaney, Ralph W.**, Cons. Engr., Box 1088, Ada, Okla. (Apr. '54) *RPD*
- DeMarzio, Joseph P.**, Chemist, Dept. of Water & Sewers, Miami, Fla. (Apr. '54) *P*
- Dewey, LaVerne I.**, Civ. & San. Engr., 11th Naval Dist. Public Works Office, 1220 Pacific Highway, San Diego 32, Calif. (Apr. '54) *MRPD*
- DeWitt, Ward L.**, Salesman, Mueller Co., 9410 Hermosa Dr., Dallas, Tex. (Apr. '54) *D*
- Dickerson, J. R.**, Sales Engr., Rockwell Mfg. Co., Box 2126, Houston 1, Tex. (Apr. '54) *MD*
- Dryden, Edward N.**, Chemist, Sanitation Dept., Ladd Air Force Base, Fairbanks, Alaska (Apr. '54)
- Dutton, Sidney**, Field Engr., Inflico (Canada) Ltd., Box 429, Adelaide St., Toronto, Ont. (Apr. '54)
- Evansdale Water Works**, Robert H. Porter, Supt., Evansdale, Iowa (Corp. M. Apr. '54)
- Fisher, Nell B.**, Instructor, Hygiene and Preventive Medicine, State Univ. of Iowa, Iowa City, Iowa (Jan. '54) *MP*
- Fletcher, D. M.**; see Westville (Natal)
- Fort Recovery Board of Public Affairs**, Vernon E. Stone, Water Supt., Fort Recovery, Ohio (Munic. Sv. Sub. Apr. '54) *MRPD*
- Foster, Joel M.**, Supt., Water & Gas Dept., Box 44, Kentwood, La. (Apr. '54) *M*
- Free, Leslie L.**, Supt., Southwest Utilities Corp., 1406 Braewick, Bellaire, Tex. (Jan. '54) *MRPD*
- Freeman, Robert S.**; see Mission City (B.C.) Corp.
- Gambrell, Dominic**, Water Comr., City Hall, Youngstown, Ohio (Apr. '54) *D*
- Garrett, Arthur**; see Quilcene (Wash.) Community Utilities, Inc.
- Godfrey, W. R.**, Mgr., James F. MacLaren Assoc., 19 Market Square, St. John, N.B. (Apr. '54)
- Grant, Francis W.**, Cons. Engr., Continental Bank Bldg., Shreveport, La. (Apr. '54) *PD*
- Greene, Gordon Z.**, Gordon Z. Greene Co., 2335 E. 8th St., Los Angeles 21, Calif. (Jan. '54)
- Gregor, John C.**, Mgr., College Crest Water Supply Dist., 224 Ingalls Way, Eugene, Ore. (Jr. M. Jan. '54) *M*
- Hamilton, Woodrow W.**, Western Mgr., Scranton Publishing Co., 185 N. Wabash, Chicago, Ill. (Apr. '54)
- Harkins, Wade**, Water Supt., Bernice, La. (Apr. '54) *M*
- Harney, Alfred A.**, Salesman, Mississippi Lime Co., Alton, Ill. (Apr. '54) *P*
- Harrison, Thomas C.**, Supt., Water Dept., Box 234, Grandfalls, Tex. (Apr. '54) *MRPD*
- Hedges, Robert H.**, Salesman, Rockwell Mfg. Co., 1249 Burlington St., North Kansas City, Mo. (Apr. '54) *MRP*
- Hernandez, Tomas H.**, Graduate Student, Civ. Eng., Georgia Tech., Box 83, Atlanta 3, Ga. (Jr. M. Apr. '54) *PD*
- Hicks, John H.**, Supt., Utilities, 429-2nd St., Aurora, Ind. (Apr. '54) *MRPD*
- Hillmiller, Ernest W.**, Supt., Water Co., Osian, Ind. (Apr. '54)

(Continued on page 92 P&R)

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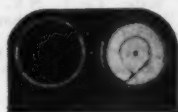
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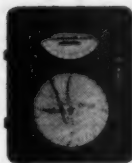
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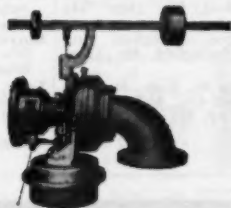
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Hintzen, Walter J., Foreman, Water Distr., Water Dept., 408 Morrissee Ave., Haledon, N.J. (Apr. '54) *MRP*

Holcomb, G. M., Engr., Kankakee Water Co., 1082 Cobb Blvd., Kankakee, Ill. (Apr. '54) *P*

Hummel, C. A.; see Jeffersonstown (Ky.) Water & Sewerage Com.

Ireland, Robert, Asst. Chief Plant Operator, Interstate Water Co., Danville, Ill. (Apr. '54)

Jackson, Virgil F., Supt. of Utilities, Vidalia, La. (Apr. '54) *M*

Jeffersonstown Water & Sewerage Com., C. A. Hummel, Secy.-Treas., 106 Taylorsville Rd., Jeffersonstown, Ky. (Munic. Sv. Sub. Apr. '54) *MD*

Johnson, Floyd L., Water Supt., Box 134, Pleasanton, Kan. (Apr. '54) *MPD*

Johnson, Gordon W., Sr. Operating Engr., Air Installations Office, Alexandria Air Force Base, Alexandria, La. (Apr. '54) *MD*

Johnson, Peter N., Asst. Supt., Springfield City Water Co., Box 709, Springfield, Mo. (Apr. '54)

Johnston, Robert W., Asst. Supt., Constr. Office, Springfield City Water Co., Springfield, Mo. (Apr. '54) *MRP*

Kiefer, Calvin G., Engr., St. Louis County Water Co., 6600 Delmar, University City, Mo. (Apr. '54) *D*

Kite, William E., Light & Water Supt., Williamsport, Ind. (Apr. '54) *MD*

Klouman, Frederick A., Director & Chief Engr., J. Blakeborough & Sons, Ltd., Woodhouse Works, Brighouse, England (Jan. '54) *D*

Lacy, Ilbert O., Chief Operator, Water Filtration Plant, Water Dept., 10 Felix St., Rochester, N.Y. (Apr. '54) *MP*

Laliberte, Andre, City Engr., City Hall, Granby, Que. (Apr. '54)

Lane, Henry T., Jr., San. Chemist, Detroit Dept. of Water Supply, 8300 W. Warren Ave., Dearborn, Mich. (Apr. '54) *P*

Leary, W. J., Director of Public Service, Civic Center, Helena, Mont. (Jan. '54) *M*

Lemonda, Asel G., Field Engr., J. B. Wilson Eng. Co., 524 K of P Bldg., Indianapolis, Ind. (Apr. '54) *R*

Lester, Lindsay, Supt., Water & Sewerage Dept., Boaz, Ala. (Apr. '54)

Lewis, Kelly B., Asst. Supt., Municipal Water & Sewer System, Magnolia, Ark. (Apr. '54) *MRP*

Lloyd, Leighton George, Supt., Div. of Water & Sewer, Mankato, Minn. (Apr. '54) *M*

Love, Leonard S., Dist. Engr., Inflico (Canada) Ltd., 2027 Mansfield St., Montreal, Que. (Apr. '54)

Lowe, Rudy P., Pres., Proportioners, Inc., Div. of B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I. (Apr. '54) *P*

Luippold, Richard B., Mgr., Luippold Eng. Sales Co., 1930 W. Olympic Blvd., Los Angeles, Calif. (Apr. '54) *P*

Malben, George, Jr., Foreman, Water Works Dept., Civic Center Bldg., Helena, Mont. (Jan. '54) *D*

Markham Water Committee, 15656 Kedzie Ave., Markham, Ill. (Corp. M. Apr. '54) *M*

Marquardt, Oscar, Chief Engr., State Penitentiary, Menard, Ill. (Apr. '54) *MP*

Martin, A. M., Supt., Public Works, Box 549, Hazlehurst, Miss. (Apr. '54) *D*

McFarland, Rolland, Tech. Director, Hills-McCanna Co., Crystal Lake, Ill. (Apr. '54) *RP*

McLellan, J. C., Accountant, Water Works, City Hall, Sydney, N.S. (Apr. '54)

McMillan, Chester C., Mgr., Borgana Products Co., Inc., 9089 N. Denver Ave., Portland 17, Ore. (Apr. '54) *P*

Menzelbauer, Fred C., Sales Engr., Wallace & Tiernan Co., Newark, N.J. (Apr. '54)

Mission City Corp., Robert S. Freeman, Clerk, Mission City, B.C. (Corp. M. Apr. '54) *MRPD*

(Continued on page 94 P&R)

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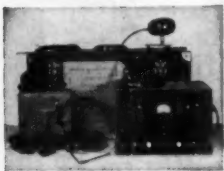
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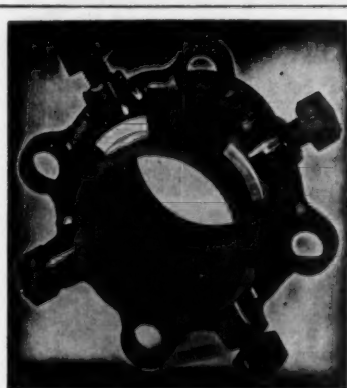
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(Continued from page 92 P&R)

- Mitchell, William H.**, Dist. Sales Mgr., Permutit Co., 407 S. Dearborn St., Chicago 5, Ill. (Apr. '54)
- Montzambert, Harry B.**, Tech. Officer, National Defence, Royal Canadian Air Force, 371 Piccadilly Ave., Ottawa, Ont. (Apr. '54)
- Moretti, Henry**, Salesman, Neptune Meter Co., 1238 N.W. Glisan St., Portland, Ore. (Apr. '54)
- Moritz, Harold K.**, Prof. of Hydr., Univ. of Washington, Seattle 5, Wash. (Apr. '54) *RD*
- Morse, Robert A.**, Supt., King County Water Dist. 42, 16906—15th N.E., Seattle, Wash. (Apr. '54) *M*
- Nichols, Irvine L., Jr.**; see Virginia State Farm
- Norman, E. O.**, Distr. System Engr., St. Louis County Water Co., 6600 Delmar, St. Louis 5, Mo. (Apr. '54) *MD*
- Onkes, Ralph W.**, Supt., Municipal Water & Light Plant, Rayne, La. (Apr. '54) *MPD*
- Pack, R. Kenneth**, Supt., Water & Sewer, Box 283, Cedar Vale, Kan. (Apr. '54) *MRD*
- Penland, Helen L., Mrs.**, Secy., Board of Water Comrs., Long Beach Water Dept., 403 Municipal Utilities Bldg., 215 W. Broadway, Long Beach 2, Calif. (Apr. '54)
- Perlis, Harry**, Mgr., Machinery Manufacturers Sales, General Electric Co., 235 Montgomery St., San Francisco, Calif. (Apr. '54) *D*
- Perry, George C.**, Dist. Mgr., Crane Co., 321 E. 3rd St., Los Angeles 54, Calif. (Apr. '54)
- Porter, Robert H.**; see Evansdale (Iowa) Water Works
- Quilcene Community Utilities, Inc.**, Arthur Garrett, Pres., Box 1, Quilcene, Wash. (Corp. M. Apr. '54) *MRPD*
- Ramsey, J. Mason**, Supt. of Water Plant, Pinconning, Mich. (Apr. '54)
- Ray, T. C.**, Supt., Water Works, Cordele, Ga. (Apr. '54)
- Riddle, Henry A., Jr.**, Atty., American Water Works Service Co., Inc., 121 S. Broad St., Philadelphia 7, Pa. (Apr. '54)
- Rindge, Samuel K.**; see Citizens Domestic Water Co.
- Ringle, Clifford**, Operator, Water Dept., Delhi, La. (Apr. '54) *P*
- Robben, C. A.**, Owner, Norton Mfg. Co., Norton, Kan. (Apr. '54)
- Saccarecia, John A.**, Asst. Hydr. Engr., State Water Power & Control Com., 90-79 Sutphin Blvd., Jamaica, N.Y. (Apr. '54) *R*
- Salas-Sivoll, Rodolfo**, Engr. of Maintenance, Instituto Nacional de Obras Sanitarias, Caracas, Venezuela (Jr. M. Apr. '54) *MRPD*
- Schade, Willard F.**, Assoc. Engr., Rollin F. MacDowell & Assoc., 401 Chester—12 Bldg., Cleveland, Ohio (Apr. '54) *P*
- Schmitt, Anthony**, Supt., Water Dept., 426 Davis St., Jennings, La. (Apr. '54) *P*
- Sherwood, Herbert P.**, Sales Engr., Permutit Co., 407 S. Dearborn St., Chicago 5, Ill. (Apr. '54)
- Shields, Wilfred H., Jr.**, San. Engr., Anne Arundel County Health Dept., Box 626, Annapolis, Md. (Jr. M. Jan. '54) *P*
- Silitch, Eugene W.**, Pres., Ranney Method Western Corp., 3526 M St., Sacramento, Calif. (Apr. '54) *R*
- Smith, Garnett A.**, Salesman, Mueller Co., Decatur, Ill. (Apr. '54) *M*
- Smith, John H.**, Supt., Water Works, Box 719, Courtenay, B.C. (Apr. '54) *MD*
- Smith, Willard W.**, Supt., Water Dept., City Hall, Delaware, Ohio (Apr. '54) *MPD*
- Snellgrove, John H.**, Sales Engr., Hersey Mfg. Co., 1544 Monterey Pass Rd., Monterey Park, Calif. (Apr. '54) *MPD*
- South Seattle Water Co.**, 11004—1st St. S., Seattle 88, Wash. (Corp. M. Apr. '54) *MD*
- Stevenson, W. J., Jr.**, Dist. San. Engr., State Board of Health, Raleigh, N.C. (Apr. '54) *PD*

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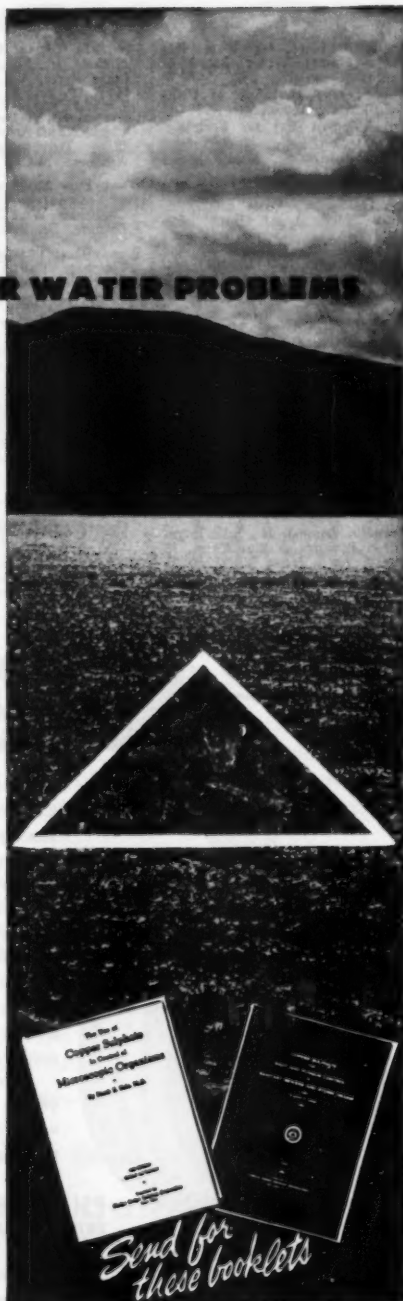
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(Continued from page 94 P&R)

Stillwell, Eldon; see West Des Moines (Iowa) Water Board of Trustees

Stockton, Roy B., Supt. of Utilities, Bartlett, Tex. (Apr. '54) *M*

Stone, Vernon E.; see Fort Recovery (Ohio)

Strawn, John M., Supt., Water Works, Board of Public Affairs, Centerburg, Ohio (Apr. '54) *MP*

Sucre, Oscar A., Chief Engr., Instituto Nacional de Obras Sanitarias, Dept. Tecnico, Puente Trinidad a Tienda Honda No. 62, Caracas, Venezuela (Jan. '54) *MR*

Sutton, James D., Supt. of Public Works, Water Dept., El Paso, Ill. (Apr. '54) *M*

Taylor, Garland S., Mgr., Consumers Water Corp., 918 Broadway, Boise, Idaho (Apr. '54) *MD*

Thissen, Joseph, Water Plant Operator, Nebraska City Utilities, Nebraska City, Neb. (Apr. '54) *MP*

Ulrich, Robert D., Water Tank Repair Mgr., Central Steel Tank Co., Box 1742, Wichita, Kan. (Apr. '54) *D*

Van Zandt, W. K., Asst. Director, Utilities Dept., City Hall, Houston, Tex. (Apr. '54)

Vetromille, Joseph R., Sales Engr., Warren Foundry & Pipe Corp., 55 Liberty St., New York, N.Y. (Apr. '54) *R*

Virginia State Farm, Irvine L. Nichols, Jr., Filtration Plant Supt., State Farm, Va. (Corp. M. Apr. '54)

Voncannon, Alta Ann, Miss., Clerk, North Asheboro-Central Falls Water Dept., Station 1 Box 23, Asheboro, N.C. (Affil. Apr. '54)

West Des Moines Water Board of Trustees, Eldon Stillwell, Chairman, West Des Moines, Iowa (Munic. Sv. Sub. Apr. '54) *M*

Westville, Township of, D. M. Fletcher, Town Engr., Box 39, Westville, Natal, South Africa (Corp. M. Apr. '54) *MPD*

Wheeler, A. Gordon, Jr., San. Engr., Nitrogen Div., Ammonia Dept. Development, Allied Chemical & Dye Corp., Hopewell, Va. (Jan. '54) *RPD*

White, Clyde, Supt., Water Dept., Tucumcari, N.M. (Apr. '54) *D*

Whiteside, William M., 1400 Swanoy Dr., Alhambra, Calif. (Apr. '54)

Whittle, John S., Supt., Richmond County Water Works, County Court House, Augusta, Ga. (Apr. '54) *MD*

Whysall, Charles C., 149 Chicago Ave., Marion, Ohio (Apr. '54)

Wilson, Francis J., Cons. Engr., 2128 E. 31st St., Tulsa, Okla. (Apr. '54) *R*

Wilson, London, Supt., Harris Co. Water Control and Improvement Dist. No. 26, 9317 Merle St., Houston, Tex. (Apr. '54) *MRD*

Wise, Don C., Supt., Russ Mitchell Inc., Box 8068, Houston, Tex. (Apr. '54) *P*

Woerheide, Russell E., Asst. Constr. Engr., St. Louis County Water Co., 6600 Delmar Blvd., St. Louis, Mo. (Apr. '54) *MD*

Wragg, Kenneth T., Mgr., Washington Water Co., 24 Belvidere Ave., Washington, N.J. (Jan. '54) *MRP*

Wright, Roy E., Chemist, Philadelphia Quartz Co. of Calif., Berkeley 10, Calif. (Apr. '54) *RP*

Yeatts, Ernest B., Cons. Engr., 1583 Cypress, Abilene, Tex. (Jan. '54) *RD*

Yellam, Robert F., Salesman, Badger Meter Mfg. Co., Milwaukee, Wis. (Jan. '54) *D*

Zellers, C. E.; see Winamac (Ind.) Munic. Light & Water Works

Zihl, Michael, Engr., Water & Sewage Treatment Dept., Freeport, Ill. (Jan. '54) *MP*



Type SM Limitorque operating 48" butterfly valve.

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The Reading Meter

(Continued from page 54 P&R)

The Control of Communicable Diseases. *Hugh Paul. Harvey & Blythe Ltd., London (1952) 526 pp.; \$9.50 in U.S. from John de Graff, Inc., 64 W. 23rd St., New York 10, N.Y.*

It is reassuring to know that in Great Britain, where compulsory vaccination against smallpox has been given up as public policy, the attitude of the public health officials on typhoid fever and the other waterborne diseases is as orthodox and vigilant as ever. In fact, the British go beyond us in one respect in the attempt to avoid waterborne typhoid:

... it is now accepted practice that all workers should be medically and serologically examined before being allowed to work in connection with the water supply where

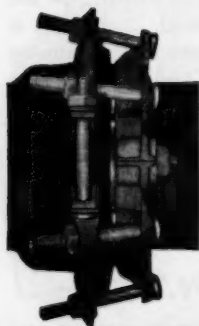
there is any possibility of their contaminating the water.

Dr. Paul also points to an additional distinction between conditions in Britain and the U.S. which presents another challenge:

Prior to 1880 typhoid fever was a disease of cities, but coincident with the improvement in public water supplies and insistence on the water-carriage system of sanitation, the higher incidence shifted to rural communities. In the United States, however, it has been shown that the maximum incidence is in small towns rather than in rural communities, and this is probably due to the fact that the small town has failed to keep up to date with regard to its sanitary provision as the town has grown, and, therefore, there is inadequate control over sewage, water and milk.

(Continued on page 100 P&R)

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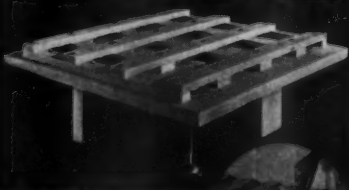


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\$43,000,000⁰⁰ HYPERION SEWAGE TREATMENT PLANT

Los Angeles, California



...protects the public water supply with Beeco Backflow Preventers

THIS BEECO INSTALLATION

was approved by local authorities and was accepted by the California State Department of Public Health as meeting the requirements of the California Administrative Code, Title 17, Public Health, 1953, entitled "Regulations Relating to Cross Connections."

ALL POTABLE WATER passes through two 8-inch Beeco *reduced pressure type* Backflow Preventers as it enters this modern sewage treatment plant. These devices are located in the service line where they protect the public water supply against possibility of contamination through backflow into the city water mains.

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Reduced Pressure
BEECO BACKFLOW PREVENTER

The Reading Meter

(Continued from page 98 P&R)

The Metco Metallizing Handbook.
H. S. Ingham & A. P. Shepard. Metallizing Engineering Co., Inc., 38-14—30th St., Long Island City 1, N.Y. (1951) 249 pp.; \$3

Although this book has been available for over two years, it warrants mention, now that we have belatedly encountered it, because it is a unique source of information on the spray application of molten metal to coat or build up the thickness of other metals. Generally used to counteract the effects of wear, as in shafts or rollers, and also to apply corrosion-resistant coatings of zinc or aluminum to ferrous metals, the method may also be used to repair blow-holes in castings, to make metallized electric circuits, to do brazing and soldering, and other work.

Information is provided on equipment, techniques of application, surface preparation, and metals that are available for spraying.

Policy Declarations on Natural Resources. *Natural Resources Dept., Chamber of Commerce of the United States, Washington 6, D.C. (1953) 41 pp.; paper-bound; no charge*

A review and restatement of Chamber of Commerce policies on federal lands, forestry, mining, national parks, petroleum, water resources, and related matters. In general, as is well known, the Chamber favors seeing less of the federal government and more of private enterprise or local government in water resources development.

(Continued on page 102 P&R)

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Water Treatment

The Reading Meter

(Continued from page 100 P&R)

Planning and Constructing Sewage Disposal Facilities. Carl M. Frasure, Harold J. Shamberger, & Eugene R. Elkins. Pub. 11, Bureau for Government Research, West Virginia University, Morgantown, W.Va. (1953) 35 pp.; paperbound; no charge

This helpful little study, prepared at the behest of the State Water Commission and the Div. of Sanitary Engineering of the State Dept. of Health, is intended to give West Virginia communities an understanding of what sewage treatment is, why it is needed, and how to go about getting it. Three documented case histories lend authenticity to the discussion, and the text of a model ordinance is provided. A section of the report discusses the advantages of operating a combined water works and sewerage system.

The Citizen Association: 1. How to Organize and Run It; 2. How to Win Civic Campaigns. Alexander L. Crosby. National Municipal League, 299 Broadway, New York 7, N.Y. (1953) two paperbound, 64-p. booklets; \$1.20 for both; either one, 75¢

The reason for recommending these blueprints for political action on a community level is not, of course, to encourage participation or promotion of citizen associations. Whatever their merits, the utility manager, particularly if he is a municipal employee, has a certain chain of command in which he must operate. The citizen association can be a help to the utility, however, and the information contained in these booklets will facilitate understanding and cooperation. Such accord will be invaluable if public support is to be mobilized for a costly construction program, a bond issue, a necessary rate increase, or other politically unpopular and therefore dangerous measure. The second of these two booklets also offers much interesting detail that may be adapted to practical campaigns in public relations.



Service Lines

A metal-cutting bandsaw that weighs only 16 lb has been developed by Porter-Cable Machine Co., 33 Exchange St., Syracuse 8, N. Y., and is described in a 4-page folder available on request. The electric-powered tool can cut pipe up to 3½ in. OD.

"The Ring-Tite Joint" is a 4-p. folder, Bul. M-1, which describes the adaptation of Rensselaer gate valves and hydrants to Ring-Tite joints to take Johns-Manville Transite Pipe. Copies may be obtained from Rensselaer Valve Co., Troy, N.Y.

Protective coatings of the Atlas Mineral Products Co., Mertztown, Pa., are the subject of an assembly of literature which has been made available by the company. The plastic-bound booklet contains approximately 50 pages of information, description, and reprints from the literature.

Centrifugal pumps in the two-stage type UNB line are described in a leaflet, Bul. W-318-S27, available from the Advertising & Sales Promotion Dept., Worthington Corp., Harrison, N.J.

"The Dorrco Aldrich PeriFilter System" is the title of a 6-p. folder which explains and describes the new package-type water treatment unit. Copies may be obtained from The Dorr Co., Barry Pl., Stamford, Conn.

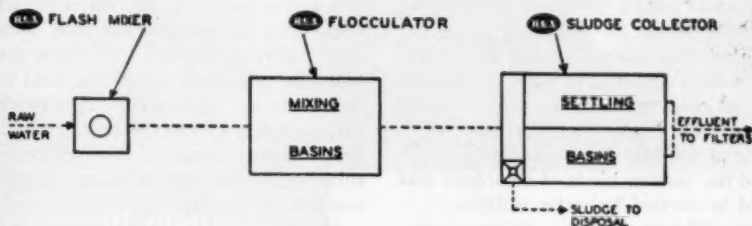
Plug valves made by DeZurik Shower Co., Sartell, Minn., are described in Catalog 54, Sec. 1, a 32-p. illustrated booklet entitled "DeZurik Easy-Operating Eccentric Plug Valves." Dimensions and operating features of the valves are given.



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Section Meetings

Illinois Section: The Illinois Section held its 44th annual meeting at the La-Salle Hotel, Chicago, on Mar. 17-19. This was the largest meeting the section ever held, with 476 persons registered. The increased interest was undoubtedly due to the severe water shortage suffered by many towns and villages over the state during the past year, and also due to the water supply problems of the many suburbs adjacent to Chicago.

The meeting started off the first afternoon with a paper by Henry A. Kudenhardt on grading of water systems by the Illinois Fire Inspection Bureau. T. J. Harris of the Maryland Casualty Co. discussed the various kinds of insurance that should be carried by water utilities.

The remainder of the afternoon was spent in a hot discussion of "Diversion of Water Works Funds." In addition to the four panelists who gave their views, there was a great amount of discussion from the floor.

Thursday morning the program started off with a paper by F. M. Middleton, of the Sanitary Engineering Center, Public Health Service, Cincinnati, on organic taste and odor substances in water, as studied by carbon filter sampling methods.

H. A. Spafford, Illinois Dept. of Public Health, spoke on the relation of cross connections and back siphonage to public health, and cited epidemics in Illinois. Several cross connections had been found in water works plants.

J. G. Praetz, Hotpoint Co., Chicago, discussed the maintenance of household appliances that require large water consumption. The proper sizes of services

and meter connections to serve modern water-using household appliances were discussed by R. H. Meeker of Belleville, who encouraged the use of larger services. House heating by the use of well water and a heat pump was discussed by Ritchie P. Dewey of Rockford.

The afternoon session started off with a paper by M. D. R. Riddell, consultant of Greeley and Hansen, Chicago, which dealt with the proper size and location of a concrete reservoir to help a system meet the afternoon sprinkling load without reducing pressures. A discussion prepared by Edwin Hancock then followed on the proper size of reservoirs in suburban towns and villages purchasing water from Chicago.

Homer Chastain, commissioner of public property at Decatur, spoke on the supply of water outside the city limits.

The discussion on "Effect of Drought in Illinois" was started off by A. M. Buswell of the State Water Survey (this issue, p. 395).

On Friday morning a very interesting extemporaneous talk was given by C. W. Klassen, chief state sanitary engineer, describing his recent trip to Borneo, where he acted as consulting engineer for the British Government in the preparing of plans and specifications for the rebuilding of the water and sewage systems of the seven principal towns in the area. The British are very much interested in the development of Borneo and of the natural resources of the country. The rainfall is very abundant, amounting to 180 inches per year, and on one day 10½ in. of rain fell in a 2-hr period.

(Continued on page 106 P&R)

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Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous pipe lines

Section Meetings

(Continued from page 104 P&R)

Merrill B. Gamet of Northwestern Technological Inst., detailed the building and design of an electrical calculator for determining the flow in city water distribution systems. Frank C. Foley followed with a paper on the geological structure of the Herscher Dome for the storage of high pressure gas in the Kankakee area. The gas is stored in the dome during the summer and then withdrawn to serve the Chicago and suburban areas during the winter.

The last panel discussion on the program was devoted to plastic service pipe. B. A. Poole of the Indiana State Board of Health reported on the progress of the study being made in Michigan on the taste, odors, and possible toxicity of plastic pipe. Elmo Conrady, water superintendent at Mount Carmel, related his experience with the use of plastic pipe. W. L. Hess, vice-president of the Anesite

Plastic Co., Chicago, discussed the specifications, weights, and thickness of various types of plastic materials now being fabricated into plastic pipes.

D. W. JOHNSON
Secretary-Treasurer

Southeastern Section: The Southeastern Section celebrated its 25th anniversary in Greenville, S.C., on Mar. 29-31, 1954, with three full days of activities. The wide variety of attractions—including the technical sessions, inspection trips, and social functions; the warm hospitality of John Hawkins, superintendent of the Greenville Water Works, his coworkers and fellow townsmen; and the efficient and satisfying manner in which the Poinsett Hotel provided for its guests, made this meeting one generally acclaimed as among the Section's best.

Total registration for the meeting, including wives and guests, was 313; the

(Continued on page 108 P&R)



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- Only 36 pounds to handle
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- Renewable bearing bronze feed yoke insert
- No disassembly to insert Corporation Stop
- Complete with chest



WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.
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Section Meetings*(Continued from page 106 P&R)*

largest attendance since the area of the Section was reduced by reorganization to its present size.

Officers elected for the next fiscal year are: chairman, W. C. Bowen, engineer-chemist, Spartanburg, S.C., Water Works; vice-chairman, Bruce J. Sams, superintendent, Savannah, Ga., Water Works; and trustee from Georgia, L. E. Wallis, superintendent, Elberton, Ga., Water and Light Dept.

A luncheon was held Monday noon, attended by about 160 members and guests, honoring John F. Pearson, Orangeburg, S.C., and William H. Weir, Atlanta, Ga., who became 25-year and Life Members respectively. Harry Jordan, Secretary of AWWA, presented the 25-year pin and Life Membership Certificate.

The Section's Annual Banquet held on Tuesday evening was attended by about

240 members and guests. Chairman Emory C. Matthews presided and Harry Jordan made a short address. The Fuller Award Committee announced that Sherman Russell, superintendent of the Atlanta Water Purification Plant, was the Section's choice to receive the Fuller Award for 1954.

Monday afternoon was devoted to an inspection of the Greenville water works system, including the storage reservoir in the mountains approximately thirty miles west of the city; the new chlorination, fluoridation, and pH adjustment equipment, and a new pumping station.

Monday evening, as guests of the Greenville Water Dept., the group enjoyed a chicken dinner at one of the popular local eating establishments.

The panel discussion Monday morning on "Water Main Failures" with Robert C. Kauffman as moderator, and Wednes-

(Continued on page 110 P&R)

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That before you experiment with substitutes in your waterworks system, you should study these facts and recognize the guarantee they offer: only cast iron pipe gives you a *proven record of economy through decades of use!* And experienced city officials have, for over three-quarters of a century, chosen Clow Cast Iron Pipe as the finest made. They know Clow offers consistent high quality, coupled with excellent service and fast delivery. They know *centrifugally cast* Clow Pipe offers longer life, greater economy and that it meets all currently approved specifications now in existence. Write today for complete, factual information.



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Section Meetings*(Continued from page 108 P&R)*

day morning on "Handling Customer Complaints," led by W. R. Wise, were particularly provocative of discussion. Humorous sidelights of the latter topic were reports by each member of the panel on fictitious complaints each had lodged with the Greenville Water Dept. sometime during the meeting and the manner in which John Hawkin's staff had handled each.

Highlights of the technical program Tuesday included talks on the use of "Water in the Atomic Engineering Program" by Winston Davis of the Atomic Energy Commission, and "Looking Back and Forward" by E. L. Filby, discussed by J. M. Roberts, which covered many things, especially the effect of industrial expansion upon water procurement and quality in the Southeast. "Training Water Works Personnel," by P. J. Philson and W. T. Linton; and "Experiences in the Use of Radio Communications in

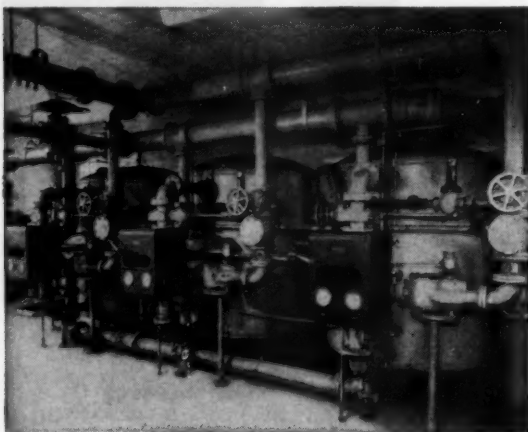
Water Works Operation," by Alan M. Johnson and Paul Weir, were equally well received.

"Meeting Water Supply Needs in the Southeast" was the subject of a most timely and informative talk given by E. L. Hendricks on Wednesday morning.

Approximately 50 wives who accompanied their husbands to the meeting were taken on an inspection trip through two of Greenville's textile plants Tuesday morning, and then to a luncheon at the Greenville Women's Club.

The Water and Sewage Works Manufacturers Assn., through a local committee headed by Charles Floyd Jr., provided Club Room facilities with refreshments, music, dancing, and other entertainment on various occasions during the meeting, adding much to the social enjoyment of those present.

N. M. DEJARNETTE
Secretary-Treasurer



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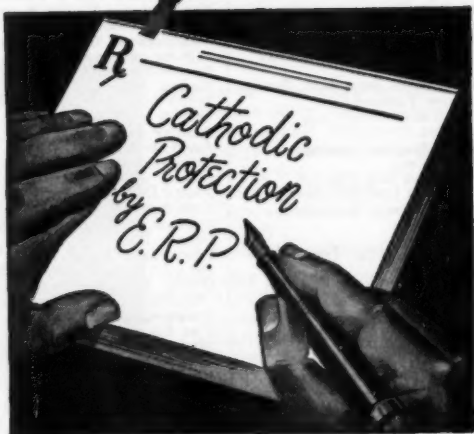
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Engineers and Chemists:
(See Prof. Services, pp. 25-29)

Feedwater Treatment:
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Belco Industrial Equipment Div.
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Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.

Permutit Co.
Ferric Sulfate:
Tennessee Corp.
Filter Materials:
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General Filter Co.

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Northern Gravel Co.
Permutit Co.
Carl Schleicher & Schuell Co.
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Dorr Co.
Inflico Inc.
Morse Bros. Mch. Co.
Permutit Co.
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Filtration Equipment Corp.
General Filter Co.
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Hungerford & Terry, Inc.
Inflico Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F
Industries)

Permutit Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Welsbach Corp., Ozone Processes
Div.

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M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.

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American Locomotive Co.
Carlson Products Corp.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
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Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
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Cochrane Corp.
Dorr Co.

General Filter Co.
Inflico Inc.
Permutit Co.
Stuart Corp.

Walker Process Equipment, Inc.
Fluoride Chemicals:
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Blockson Chemical Co.
Henry Sundheimer Co.

Fluoride Feeders:
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Omega Machine Co. (Div., B-I-F
Industries)

Wallace & Tiernan Co., Inc.

Furnaces:
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Furnaces, Joint Compound:
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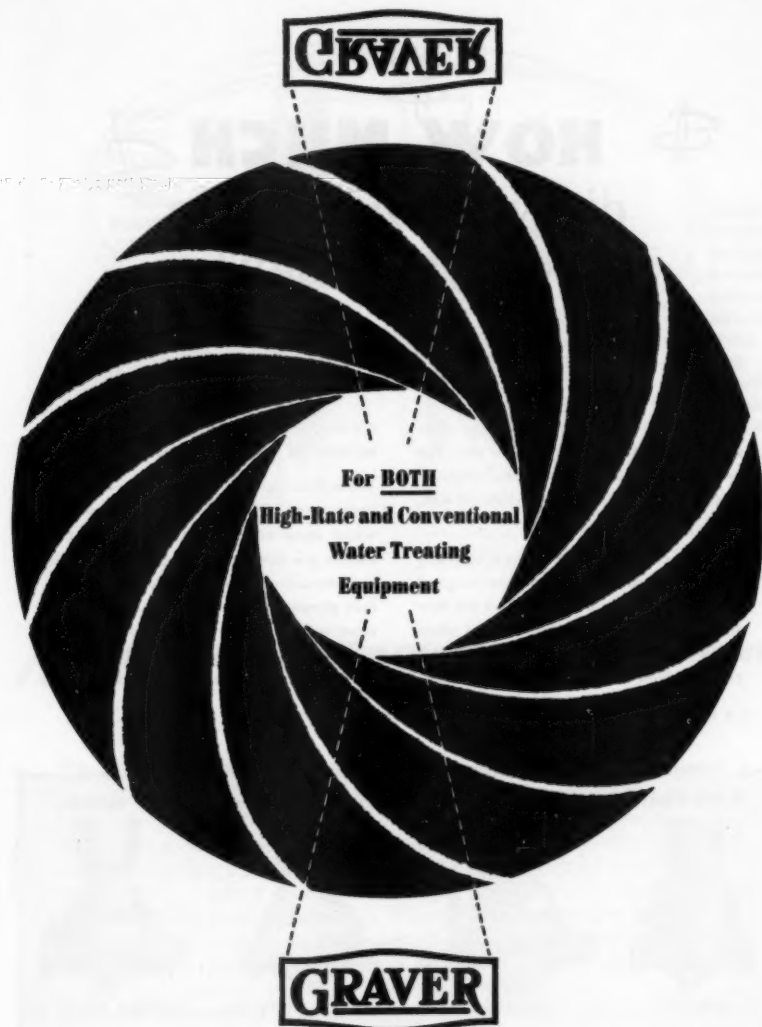
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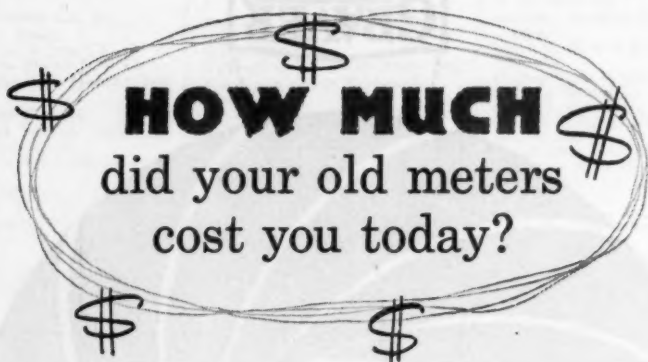
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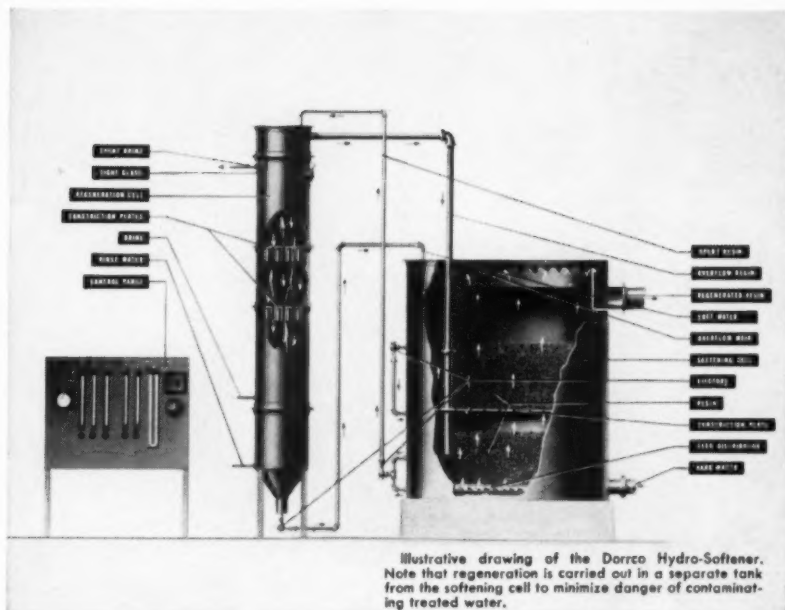


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